

the magazine of aerospace technologies / APRIL 1960

space aeronautics

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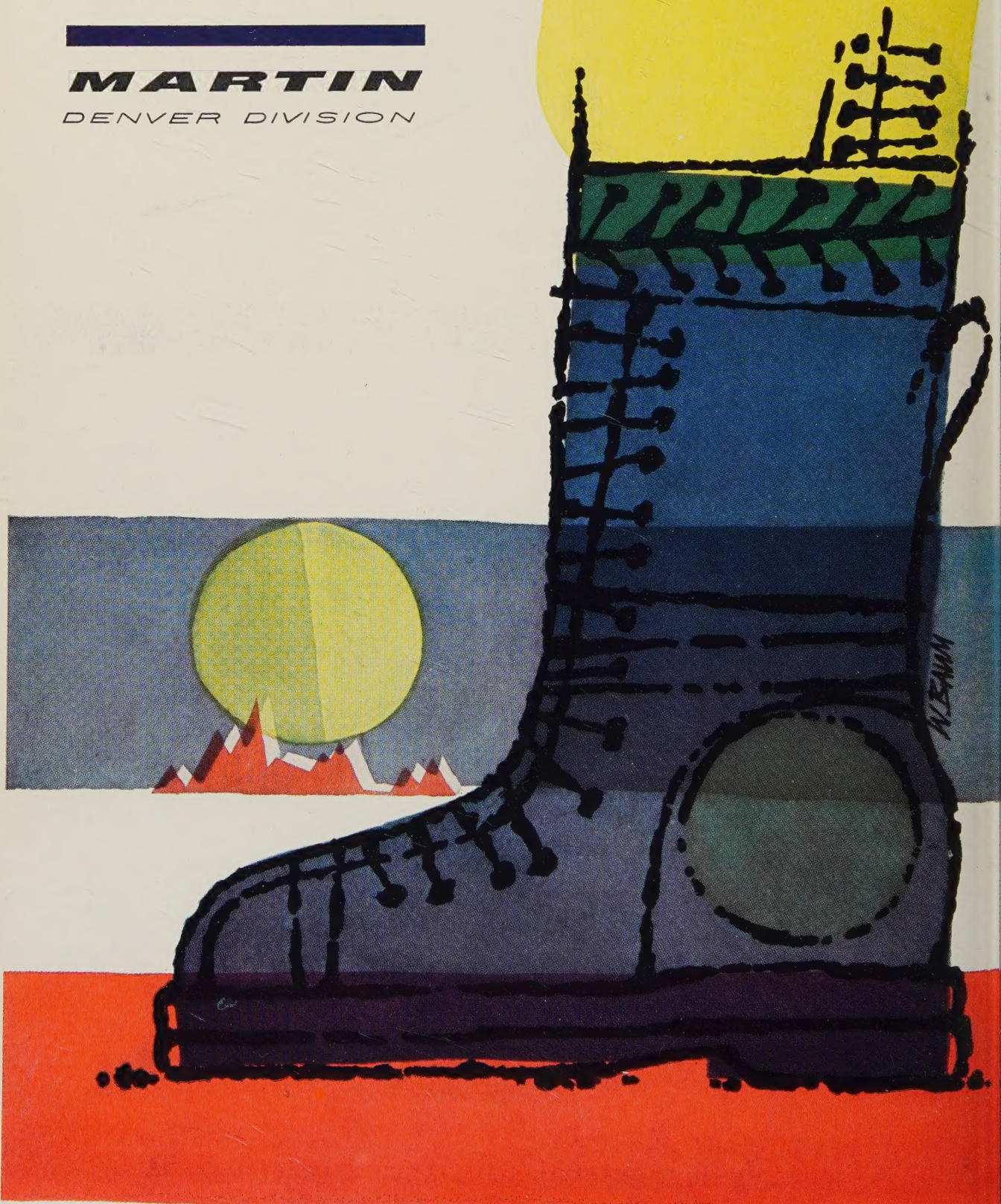
CHICAGO MIDWAY LABORATORY

SPECIAL REPORT: electronic countermeasures

TAKE A GIANT STEP

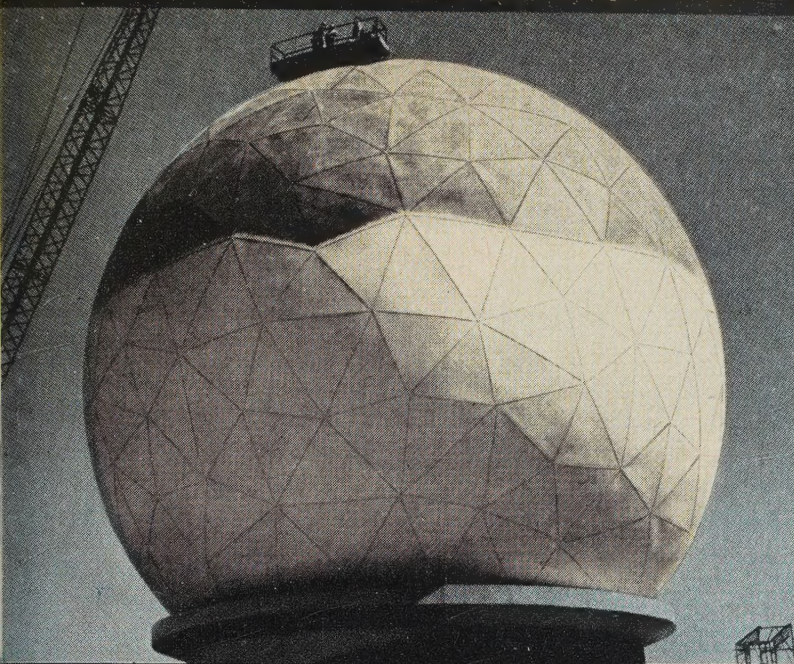
... into your future and seek out the professional opportunities awaiting creative engineers and scientists at Martin-Denver... For here exists the most challenging problems in space and human engineering. Join with us and communicate with N. M. Pagan, Director of Technical and Scientific Staffing (Dept. AA-10), The Martin Company, P. O. Box 179, Denver 1, Colorado.

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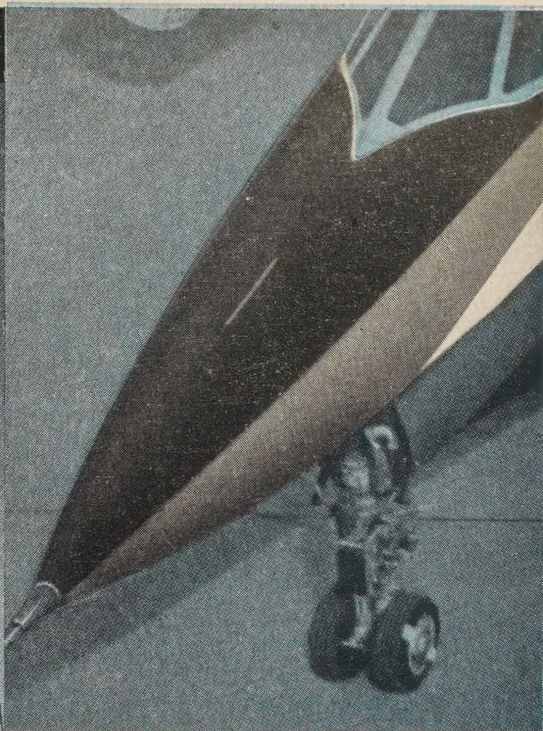


The eight divisions of the Martin Company are Activation, Baltimore, Cocoa, Denver, Nuclear, Orlando, RIAS, and Space Flight.

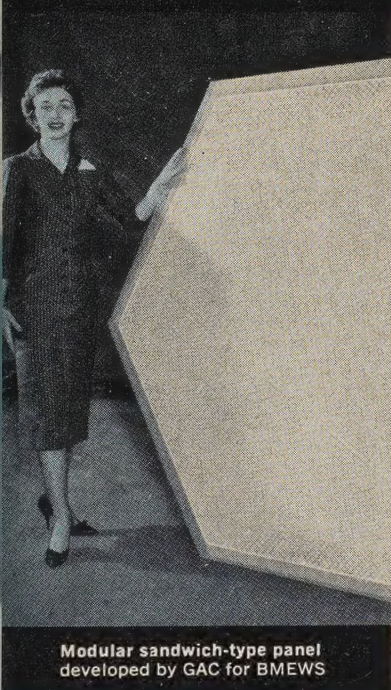
RADOMES: another prime capability of Goodyear Aircraft



110-foot rigid radome, pioneered by GAC



Solid laminate radome for Mach 2 airplane



Modular sandwich-type panel developed by GAC for BMEWS

Here's **FULL COVERAGE** for radar

Whatever your radome requirements, chances are Goodyear Aircraft Corporation (GAC) has built one like it. For GAC has pioneered radome development — from the smallest aircraft and missile radomes to giant ground radomes for BMEWS and Nike-Zeus. Whether you need a "foamed in place" or honeycomb-sandwich construction, a ducted radome design or a solid laminate model — Goodyear Aircraft has the answers to the problem — electrical and mechanical design, fabrication, testing, erection and service. Your inquiry is invited. Write: Goodyear Aircraft Corporation, Dept. 916 BP Akron 15, Ohio.

GOOD YEAR AIRCRAFT

Providing all 3
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DESIGN

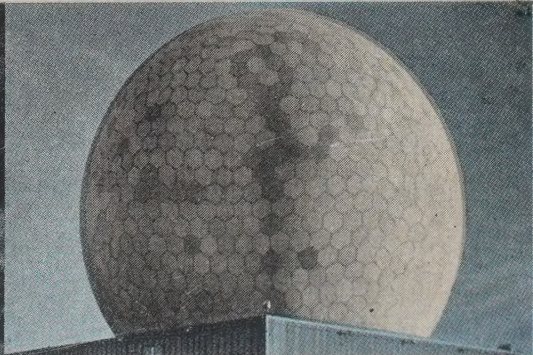
MANUFACTURE

MANAGEMENT

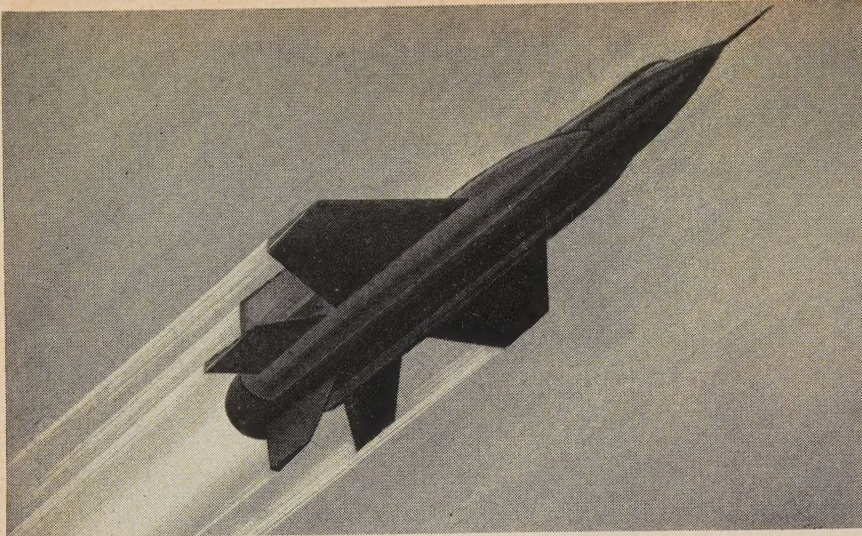
Plants in Litchfield Park, Arizona, and Akron, Ohio



Cored deicing radome, built by GAC for C-130

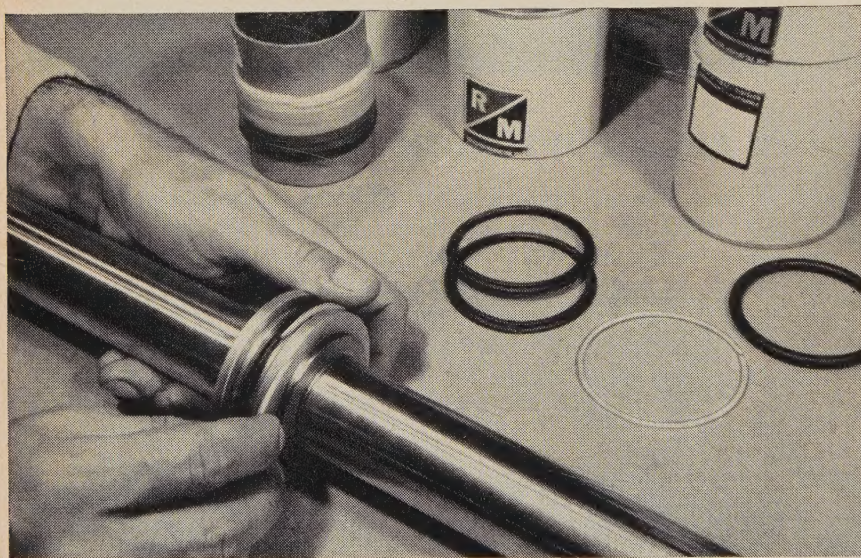


140-foot honeycomb sandwich radome



R/M CAPABILITY

*fabricates high-temperature-pressure
anti-extrusion rings for a rocket plane*



Raybestos - Manhattan capability was clearly demonstrated when it solved the extremely difficult problem of fabricating anti-extrusion rings for a super-secret rocket plane.

Pinhole leaks in components of the plane's hydraulic system centered in buffer areas between the moving parts. One such leak in a duct might result in total loss of a \$50,000,000 rocket plane.

R/M was given the problem of fabricating filled Teflon* anti-extrusion rings which would not depart from ID, OD and thickness

tolerances by more than $\pm .001$ inch.

R/M, using its pre-stabilized Teflon stock and newly developed diamond-face cutting tools, fabricated the rings and then machined them to the required tolerance in sizes ranging from 1/8 to 8 in. OD.

Anti-extrusion rings are but one example of R/M capability in action. Fire wall protection, tadpole tape, channel tape, and other products put R/M capability to work. Write and tell us about your specific sealing problems and ask for our literature.

*A Du Pont trademark



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MECHANICAL PACKINGS AND GASKET MATERIALS

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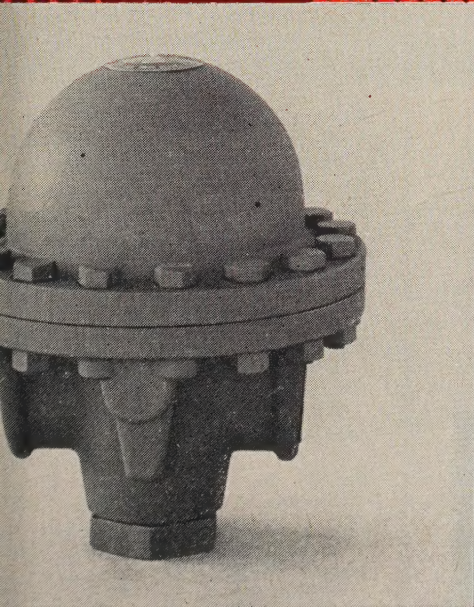
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SPACE/AERONAUTICS



INSTANTANEOUS RESPONSE

Grove Regulators... For over twenty years—from the first missile experiments in the Navy Experimental Station at Annapolis to the launching pads at Cape Canaveral—setting the standards for the control of high pressure fluids ...the regulators which served as the critical control on World War II flame throwers and torpedoes...and made missile development work possible...Grove High Pressure Regulators...frequently imitated but never equaled.

owreactor Dome Regulator—Model GH-408 • 50-6000 psi inlet...5-3000 psi reduced pressure

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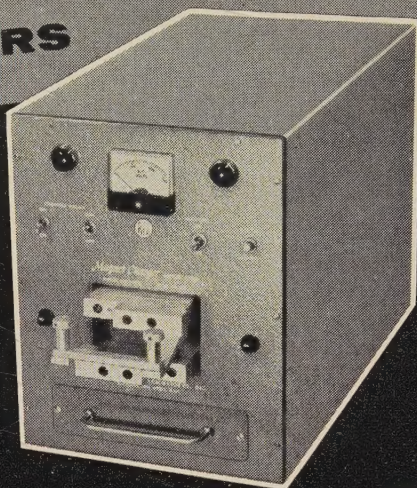


from Magnet Charger

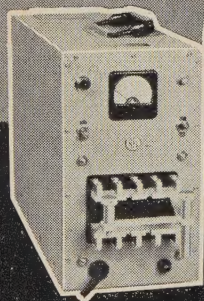
HEADQUARTERS

MODEL 1500

with
Dual Ranges
to 40,000
Ampere-Turns



3 VERSATILE MODELS



MODEL 107A

Designed for production, research and instrument repair work, the Model 1500 will magnetize the new cobalt platinum and barium ferrite materials as well as all the Alnicos. It will saturate large switchboard meter assemblies and all panel type instruments and uses most existing adapters designed for the Model 107A. Wire-wound fixtures are plugged into front panel through a safety interlock system providing maximum operator protection. Operates from 115-volt, 60 cps line. Size 11 x 20 x 15; weight 125 lbs. Price \$995.

A basic condenser discharge unit for most medium size magnets, the Model 107A provides ranges of 12,000 and 24,000 ampere-turns. It is capable of saturating most instrument magnets, including the new core type mechanisms, using adapters or wire-wound fixtures. Designed for continuous duty. Operates from 115-volt, 60-cycle line. Price \$590.



MODEL
942

A high powered magnetizer (up to 200,000 ampere-turns) capable of charging large Alnico and ceramic magnets of various shapes or pole configurations. Adapters for multi-pole rotors, rod, bar, ring and other shapes are available. Designed for continuous production use. Size 30" x 33" x 38"; weight 235 lbs. with 200-uf unit. Price of basic unit is less than \$2100.

Performance of all models is rigidly guaranteed. Prices are net f.o.b. Boonton, N.J. and subject to change without notice.

13 years' magnet charging experience is yours for the asking—send for illustrated data sheets.

WE CAN
HELP
YOU



Radio Frequency
LABORATORIES, INC.
Boonton, New Jersey, U. S. A.

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cover story



What amounts to a barrier of silence is being broken in this month's special report on *electronic countermeasures* (beginning on page 120). Outside of the classified literature, you'd probably have a hard time finding so much information on ECM and ECCM in a single package as is presented here by SPACE/AERONAUTICS' electronics editors. The special report features three staff-written articles (a survey of the ECM market, a review of the fundamentals of ECM design, and a forecast of ECM developments in space), a series of articles by ECM specialists on outstanding design problems, a collection of nomographs and a comprehensive listing of the industry's ECM capabilities.

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SPACE/AERONAUTICS



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HYATT **HY-ROLL BEARINGS**
 ROLLER BEARINGS IS THE WORD FOR  **RELIABILITY**
 HYATT

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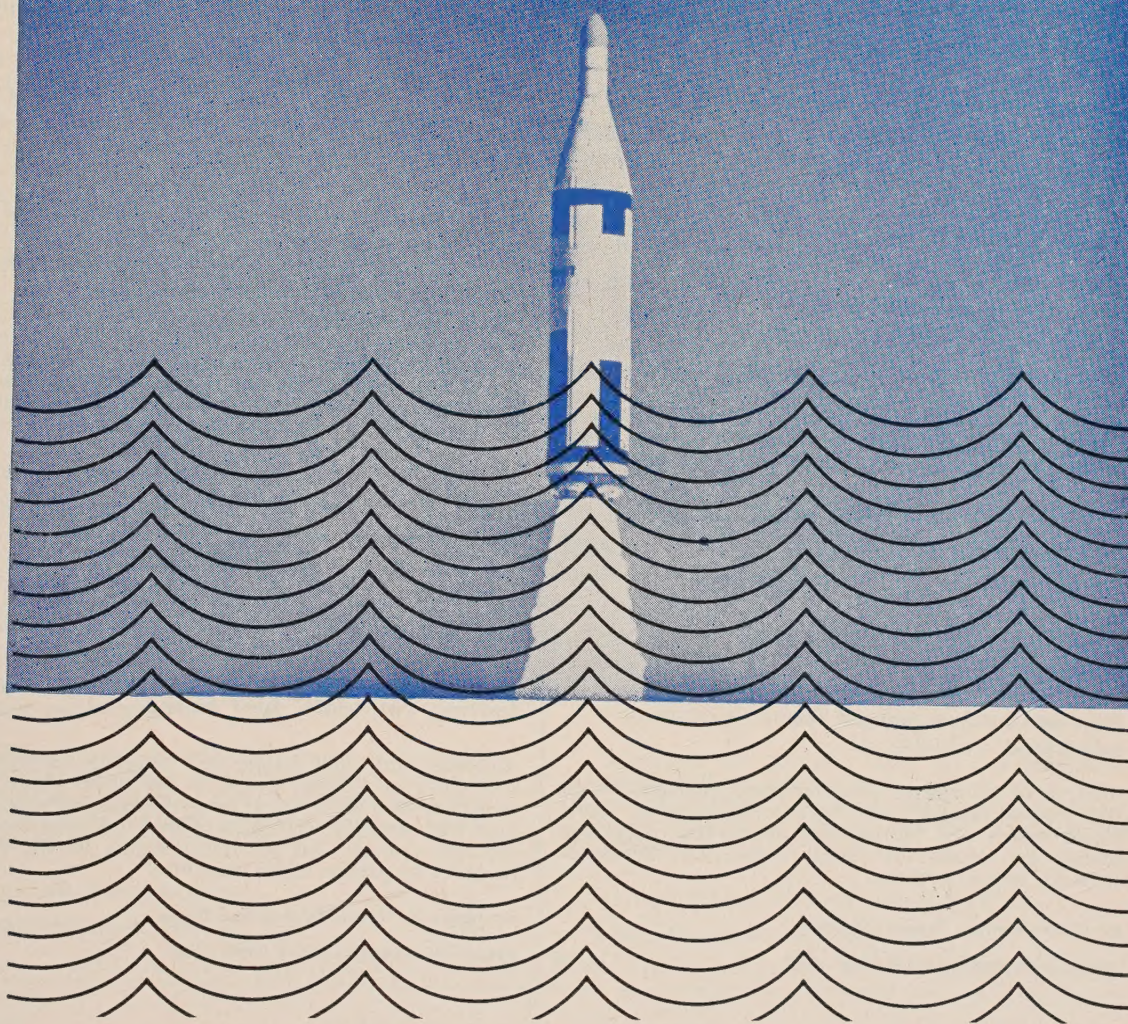
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The editorial content of SPACE/AERONAUTICS is regularly examined for readability by Robert Gunning Assoc., consultants in clear writing. These consultants meet periodically with the editors and discuss comparative readability ratings.



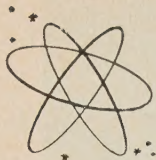
Avco "primes" America's newest peacemaker — Newest weapon in America's atomic defense is the Navy's submarine-launched missile, Polaris. The critical job of making sure the Polaris detonates on time and on target was handled by Avco's Crosley Division. Arming and fuzing for the Polaris—like the recent development of the Air Force's Titan nose cone—is typical of Avco's role in U. S. missilery.

Avco

AVCO CORPORATION, 750 THIRD AVENUE, NEW YORK 17, N.Y.

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UNUSUAL CAREER OPPORTUNITIES FOR QUALIFIED SCIENTISTS AND ENGINEERS... WRITE AVCO TODAY.



in this issue

Here's a quick rundown of the technical information offered in the articles in this issue. You can also use these article abstracts to build up your own permanent record for reference in the future—just clip them, paste them up on standard three-by-five cards, and file them.

Aerospace Engineering
Propulsion

Astia code: 27-3
Your code:

Ion rockets give top specific impulse

General design review of ion propulsion problems. Configurations of ion generators and accelerators are discussed, and the requirements for working fluids and materials are analyzed. Performance data for ion rockets and other electric rockets are compared.

by Kurt R. Stehling, Contributing Technical Editor
space/aeronautics 33/4 (Apr. '60)

p. 44

Aerospace Engineering
Structures, Accessory Systems

Astia code: 1-3
Your code:

Built-in damping: new answer to structural vibration

Discussion of use of metallic or viscoelastic inserts or strips in structural members to provide damping of resonant vibrations at a minimum weight penalty. Data are compared for damped members and conventional solid structural elements.

by Jerome E. Ruzicka, Barry Controls
space/aeronautics 33/4 (Apr. '60)

p. 61

Aerospace Engineering
Accessory Systems

Astia code: 1-2
Your code:

Gear drive reliability starts in preliminary design

Analyzes pitfalls of transmission design. Reviews data available from gear manufacturers and data designers must develop on their own to insure reliability. Analyzes rating standards in terms of operating speed, power dissipation, gear accuracy, finish, and backlash.

by Nicholas S. Hodska, Sikorsky Aircraft
space/aeronautics 33/4 (Apr. '60)

p. 47

Aerospace Engineering
Production Engineering, Materials

Astia code: 17-4; 26-1
Your code:

Tungsten plating made easy by vapor deposition

Description of new method for plating high purity tungsten on metal surfaces, as developed by National Bureau of Standards. Also presented are some recent data on high temperature properties of tungsten.

by Irwin Stambler, Associate Editor
space/aeronautics 33/4 (Apr. '60)

p. 75

Aerospace Engineering
Accessory Systems

Astia code: 1-2
Your code:

Non-propulsive power for advanced vehicles—II

Analysis of advantages, disadvantages, application areas, and growth prospects for battery; solid-fueled; liquid-fueled mono- and bipropellant open cycle, expansion-engine; and chemically fueled closed-cycle thermomechanical power systems.

by Robert Curran, Boeing Airplane
space/aeronautics 33/4 (Apr. '60)

p. 50

Aerospace Engineering
Testing

Astia code: 30-4, -5
Your code:

Testing full-scale fuel tanks

Rigorous static and fatigue test program for full-scale fuel tanks of Convair F-106 is described. Made under environmental flight conditions, the tests covered static load and pressure, statically applied repeated load and pressure cycling, and dynamic loading at the natural resonant frequency of the structure.

by James K. Neary, Convair-San Diego
space/aeronautics 33/4 (Apr. '60)

p. 83

Aerospace Engineering
Systems Engineering, Dynamics,
Structures, Production Engineering

Your code:
Astia code: 1-2, -3; 26-1

Grumman Gulfstream features low power loading (Design Progress)

Structural drawings and assembly diagrams are given for major parts of Grumman Gulfstream executive turbo-prop transport. Performance parameters are discussed.

by Irwin Stambler, Associate Editor
space/aeronautics 33/4 (Apr. '60)

p. 55

Aerospace Engineering
Accessory Components, Structures

Astia code: 1-2
Your code:

Shock strut valve halves pulse loads

Design analysis and evaluation of bandpass shock strut designs. Shows results of tests with conventional fixed-orifice struts as well as schematic of superior "floating-piston" low-bandpass shock absorber.

by Emanuel Schnitzer, NACA
space/aeronautics 33/4 (Apr. '60)

p. 93

To make filing easier, each abstract is coded according to the Astia Distribution Guide. Copies of this guide are available from Armed Services Technical Information Agency, Arlington Hall Sta., Arlington 12, Va. There is also room on the abstracts for you to insert your own key if you use a special coding system.

Astia code: 8
Your code:

p. 138

Astia code: 8
Your code:

p. 143

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p. 147

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p. 157

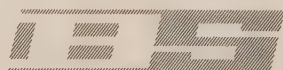
Space probe reaches
heights of over 500 miles—
speeds of over Mach 10—
with unprecedented reliability ...

... AND BRISTOL SIDDELEY SUPPLY THE POWER

One of the largest manufacturers of motive power units in the world, Bristol Siddeley Engines Limited produce the Gamma. A liquid propellant rocket engine, the Gamma powers the Saunders-Roe Black Knight, Britain's highly successful space research vehicle. An extremely reliable powerplant, the Gamma produces a total sea-level thrust of 16,400 lb (7,438 kg) and nearly 19,000 lb (8,618 kg) outside the earth's atmosphere, for a total powerplant weight of only 700 lb.

The Gamma has sent Black Knight over 500 miles into space at speeds in excess of Mach 10 with a reliability that is unprecedented. For, to date, the Gamma has never failed to fire successfully.

Since Bristol Siddeley's rocket division began work in 1946, it has developed a wide range of components. By combining these components in single or multi-chamber layouts, thrust requirements from 500 lb up to 100,000 lb can be met.



BRISTOL SIDDELEY ENGINES LIMITED

Bristol Aero-Industries Limited, 200 International Aviation Building, Montreal 3, Canada. Telephone: University 6-5471

POWER FOR THIS



... AND THIS



AND THIS



Bristol Siddeley Maybach diesel engines power Britain's fastest express train.

The Bristol Siddeley Orpheus powers the Fiat G 91.

The Bristol Siddeley Proteus powers the Britannia airliner.

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Special Report:
Electronic Countermeasures

Astia code: 8-1
Your code:

Wide bandwidth, high power handling abilities needed for ECM antennas

Discussions of different types of antennas used for electronic countermeasures systems and the applications of each. Antenna arrays are also reviewed.

by E. C. Hatcher, Electronic Specialty

space/aeronautics 33/4 (Apr. '60)

p. 171

Special Report:
Electronic Countermeasures

Astia code: 8
Your code:

Industry capabilities

Listing of companies engaged in countermeasure, counter-countermeasure, or electronic-recon work, showing contractual experience and fields of specialization. University and military activities in electronic warfare are also outlined.

space/aeronautics 33/4 (Apr. '60)

p. 183

Use the

"Time-Saver" . . .

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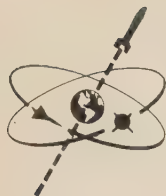
DO YOU RUN into trouble when you try to visualize three-dimensional problems involving angles—in working on an inertial system, say, or a multi-gimbaled platform? Then watch for a new SPACE/AERONAUTICS series, beginning next month, which presents in detail a proved, simplified method for visualizing and manipulating the relationships between the quantities involved in three-dimensional design.

ANOTHER SPACE/AERONAUTICS series will wind up next month: our coverage of the state of the art in exotic metals. A detailed article reporting on two of these materials will round out a sequence of articles that started several months ago and in the course of which metals like tungsten, molybdenum, chromium, rhenium, etc., have been treated.

MORE "EXOTIC" stuff will be presented in the concluding article of the current series on non-propulsive power for advanced vehicles. Next month's article will deal mostly with nuclear and solar power sources and evaluate them in comparison with the chemical designs covered earlier.

coming soon

FOR ITS NEXT special report, SPACE/AERONAUTICS has chosen the field of VTOL, STOL, and ground-effect aircraft. This report, which will cover developments both in this country and abroad, will outline the market represented by these designs, discuss the latest engineering developments and trends, and present detailed specifications and performance data on current vehicles.



Report from our ICBM base

A SMALL ITEM in the papers the other day said that our only operational Atlas ICBM blew up during a fueling operation. A few days earlier *U.S. News & World Report*, in a story designed to show our ICBM strength versus the Russians', stated that the Atlas ICBM squadron at Vandenberg AFB, Calif., "has 10 missiles, half of which are being used for training, with four or five kept ready for emergency use if war comes."

The two reports piqued our curiosity—factually they seemed quite a bit apart. Those trying to keep in touch with the realities of our defense "posture" might be confused, if they saw both reports, or reassured more than they should be, if they saw only the *U.S. News* story.

S/A engineer-editor tours Vandenberg

We therefore were quite interested in the report made to Editor Randolph Hawthorne by associate editor Irwin Stambler. Irwin made the same tour of Vandenberg that the *U.S. News* article was based upon. This is his routine report picked out of our editorial trip files:

"Just got back from the first really comprehensive tour the military has given of Vandenberg AFB. It was hardly reassuring.

"They showed us all the installations for missile launching, either complete or in progress. This included the 'soft' Atlas complex, which is made up of three pads and the only operational ICBM launchsite in the U.S.

"However, at this 'operational' site, only one missile actually was ready to go if the button had to be pushed. The missiles on the other two pads were in various stages of checkout.

"Also completed were three horizontal Atlas pads, on which the missiles can be kept horizontal inside a shelter for checkout. They were being manned and were instrumented for crew training. Conceivably they could be used in an emergency, but it would take time to get an experienced crew in to take over. Three more horizontal types were under construction.

"They also took us through the first underground Titan silo being built in the U.S., which is near completion. Very impressive to look down 155 ft into the ground standing beside two 280-ton concrete doors at the top. An Atlas silo under construction is to be 174 ft deep. But, of course, the question arises as to just

how vulnerable all these sitting-duck sites may be.

"In fact, after going all through the complex, seeing the tremendous number of gadgets and checkouts required for each, and considering the fact that once a missile is launched it will take days of reworking the pad before another one can be launched, you start to wonder. (About reworking: The tremendous blast from the ICBM engine ruins many cables, launch attachments, etc. These items must all be replaced for another launch.)

"At the present state of the art, if we had several hundred missiles at the 'ready', probably half would not be ready to be fired in case of emergency. Of the rest, it's obviously doubtful how many actually would 'go'.

\$2 million for concrete and steel

"About the underground silos, I was told that the concrete and steel work alone cost \$2 million. Obviously, the price goes much higher when electronics, fuel, etc., are taken into account.

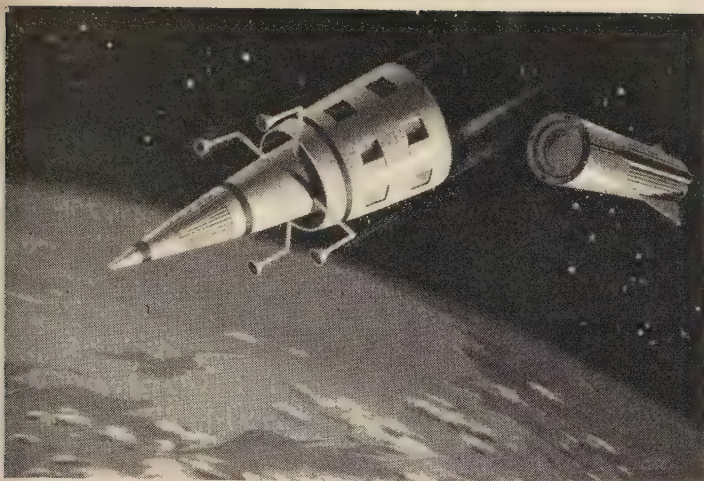
"So the thought struck me that we're crazy as can be to depend on ICBMs alone at this point. (Also considering that once an ICBM is launched, you can't call it back.)

"It will be several years, perhaps many, before ICBMs are out of the horse-and-buggy stage. Seems to me we ought to push production programs of reliable B-58s and other advanced aircraft in the interim."

Irwin's observations bring home to us that all this talk about the "missile gap," "strategic deterrent," and all that, may be academic. Perhaps a few inputs from the operational side should be cranked into the decision-making machinery in the Pentagon and the White House.

Irwin's remarks also show that the inexperienced eye of the non-technical press can be bamboozled by outward appearances.

William L. Maass
Publisher



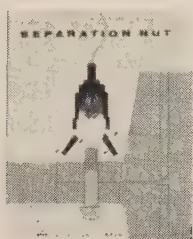
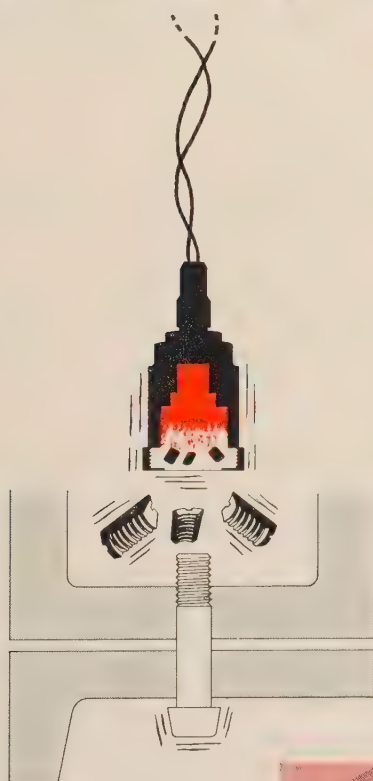
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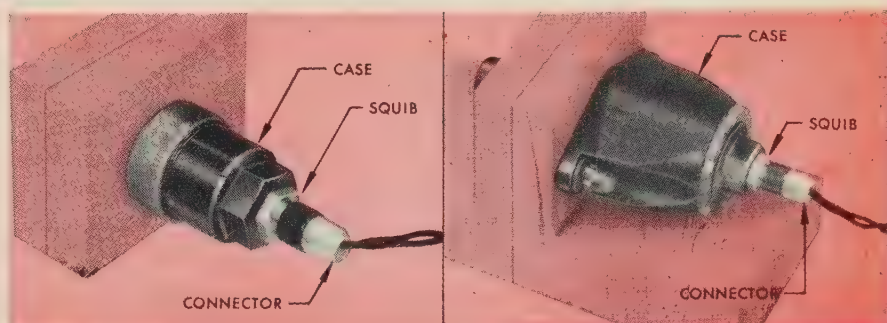
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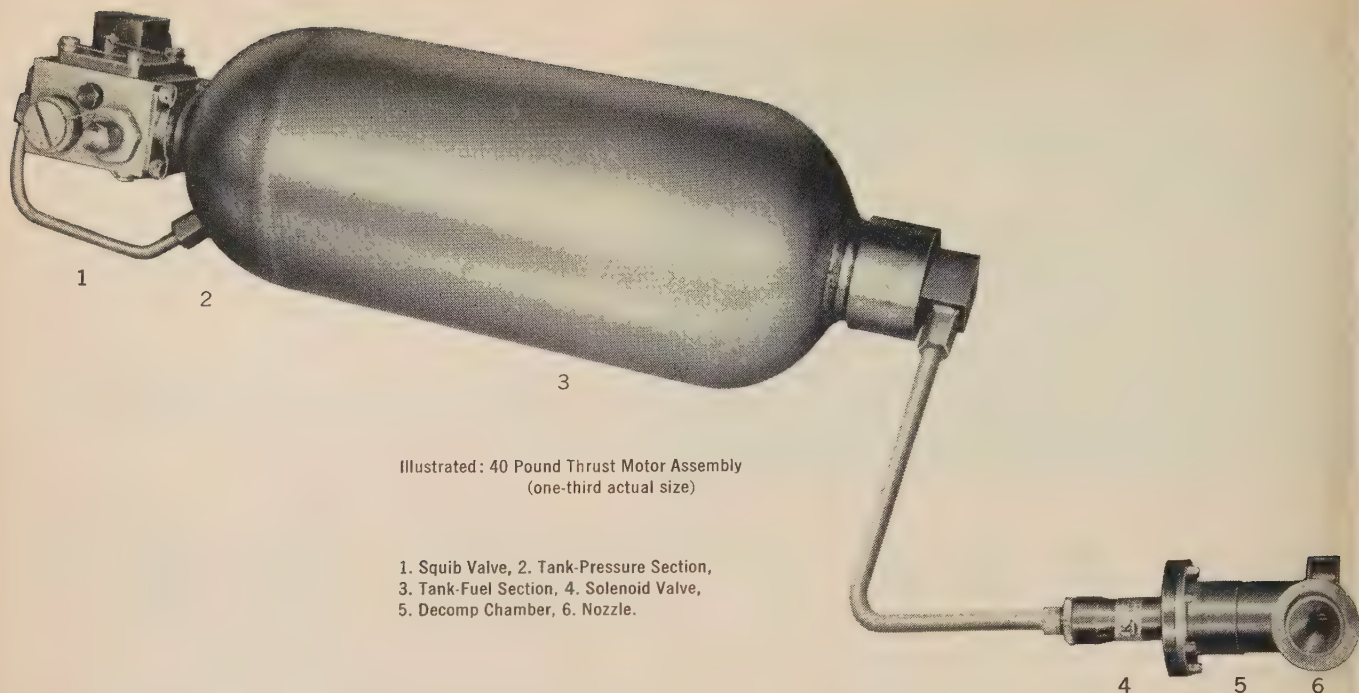
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SPACE/AERONAUTICS



editorial

"Each year we are slipping . . ."

THE DEFENSE debate now raging shows one thing: Everyone is talking details that confuse and deceive. The defense problem isn't the "missile gap", the "manned aircraft gap", or any other "gap". These are but symptoms of a disease.

The President quite honestly can claim we are stronger militarily than ever before. The hard fact is that were the Soviets to attack now, they'd be wiped out.

Then what is all the fuss about? It's about our future strategic deterrent power, and our "shrinking capabilities".

The House defense budget hearings showed that, in line with the President's "minimum" deterrent concept, our defense establishment is cut to the bone. There are little or no reserves beyond a cataclysmic "Sunday" punch.

THE PICTURE now is this: We are building barely enough of our strategic war deterrent, and we are jeopardizing its future power by disagreement and lack of decision on future weapon systems requirements. At the same time we are slowly starving our capabilities to deter local wars that threaten our strategic position.

Navy chief Arleigh Burke voiced the real defense question: "The thing that worries the Navy most is the future capabilities. Each year we are slipping a little bit . . . but this budget meets our present requirements."

The same can be said of the Air Force, Army, and Marines. Each service each year is "slipping"—and not always so little—in men and in numbers of weapons. But this budget meets "present" requirements.

We are getting a bigger "bang" per weapon per man. The President therefore feels justified in reducing our overall forces. However, the paradox is, that, as we grow "stronger," our capabilities are shrinking. This means we can take care of fewer "situations," although our overall military power is greater.

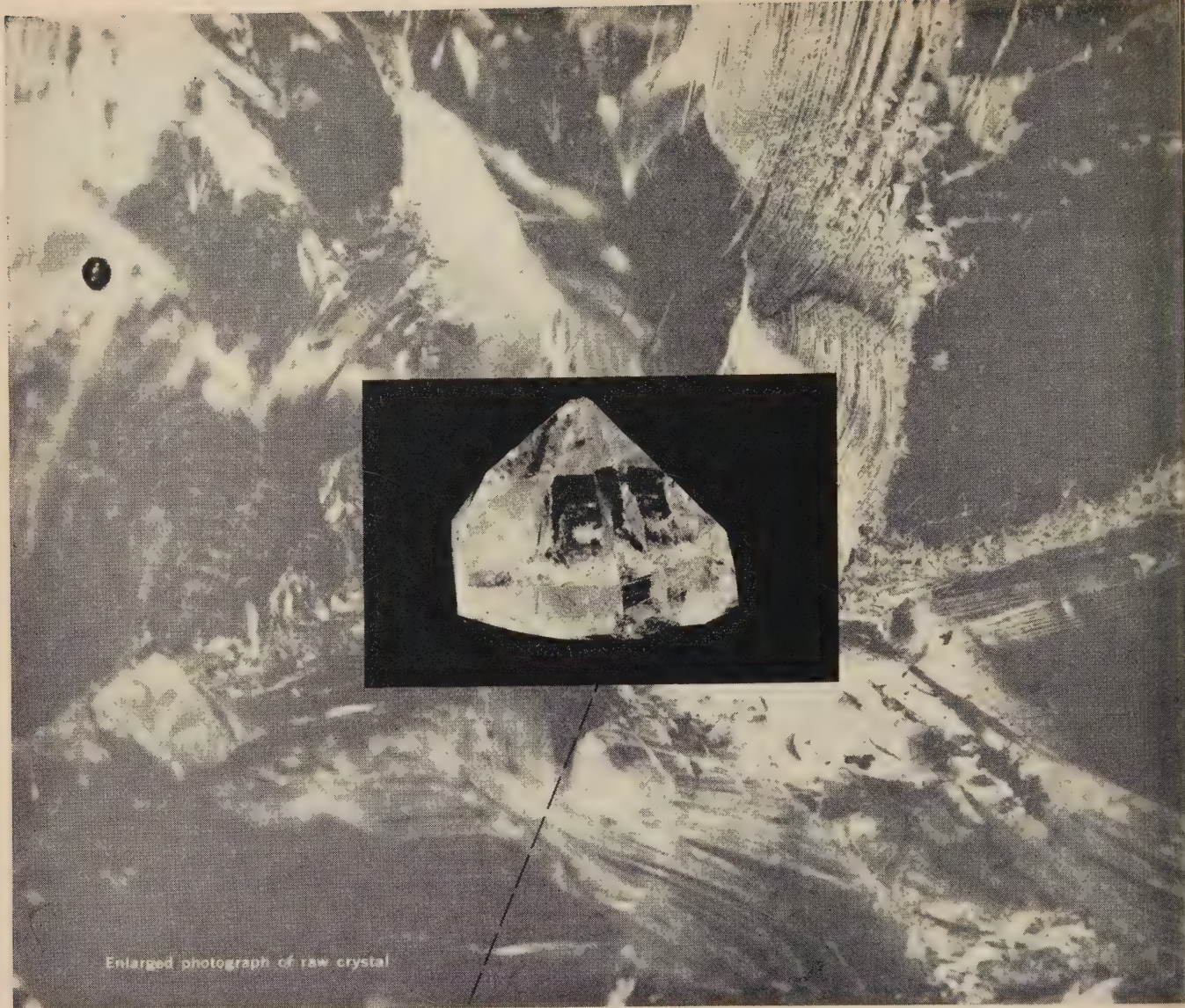
PROGRAMS now under way will determine our strategic and tactical power in the mid-sixties. If they are not on time, we won't have the power needed. Choosing the right programs takes great technical knowledge and military foresight, based on an intimate knowledge of advanced weapon systems and on intelligence of future enemy capabilities and trends. These details the President now does not understand, and should not be expected to understand.

Expert technical and military opinion is in favor of a full B-70 program. This manned supersonic, long range North American Aviation bomber does not compete with ICBMs except in dollars. Both weapons are vital to our future strategic power.

At the same time, we need not just the bigger "bang" per weapon per man. We also need more weapons, more equipment, and more men to meet the local war threat.

How much is needed for strategic or tactical war forces is determined by the military missions and responsibilities laid on the services, and by intelligence estimates of enemy military threats now and in the future.

Randolph Hawthorne, Editor



Enlarged photograph of raw crystal

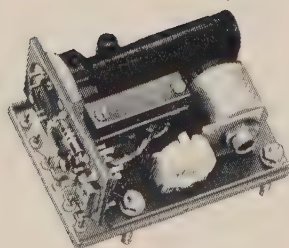
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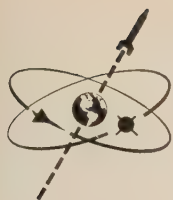


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SPACE/AERONAUTICS



washington briefing

by **A. N. Wecksler** and **R. M. Loebelson**, Washington Bureau Chief and Associate Editor

Who evaluates NASA's planning?

WHILE the score card on space exploration varies from time to time, and invariably is weighed in favor of the Soviets, the final tally may well be written based on the decisions of Program Planning and Evaluation of NASA.

Four scientists and a director sit in judgment over the programs and intentions of NASA, and while they do not have the final word over what projects we will undertake in space, their evaluation is significant in many of the final decisions that are made.

Specifically, the Program Planning and Evaluation function is aimed at a technical review of projects underway, and plans for the future by an unbiased scientific group.

There are many and various decisions that have to be made as to the competence of a current investigation, and as to what will follow—such questions as to what the followup booster should be in the Saturn project, whether solid or liquid; the adequacy of the tracking system; how contracts are going; whether the investigation of high energy propellants is going as fast as the technology makes possible. All of these are grist for the NASA evaluation mill.

Another area of evaluation is a review of major payloads (1,000 lb and over)—whether proposed payloads conform with NASA objectives.

The four scientists who evaluate the NASA programs specialize in propulsion, electronics, guidance, missile design and general science. In each case, they closely watch the contracts involving their fields of competence. They follow the progress, and, with their background, can detect whether some contract might create an area of concern. The Program Planning and Evaluation Group scans all progress reports coming in to NASA, and carefully reviews reports on projects with an inherent problem.

Where there is an area of investigation that holds the possibility of a break-through, the review is much more intense.

What happens with the yield of all the planning and evaluation work? In evaluating the work of NASA, the planning group can come up with specific proposals and these are forwarded to the NASA Administrator for action.

Such proposals may lead to the calling of a meeting by NASA Administrator Dr. T. Keith Glennan, who will get all interested parties together to con-

sider a proposal that calls for a basic decision.

In addition, there are regular weekly senior staff meetings, and periodic meetings which include the directors of all the NASA labs.

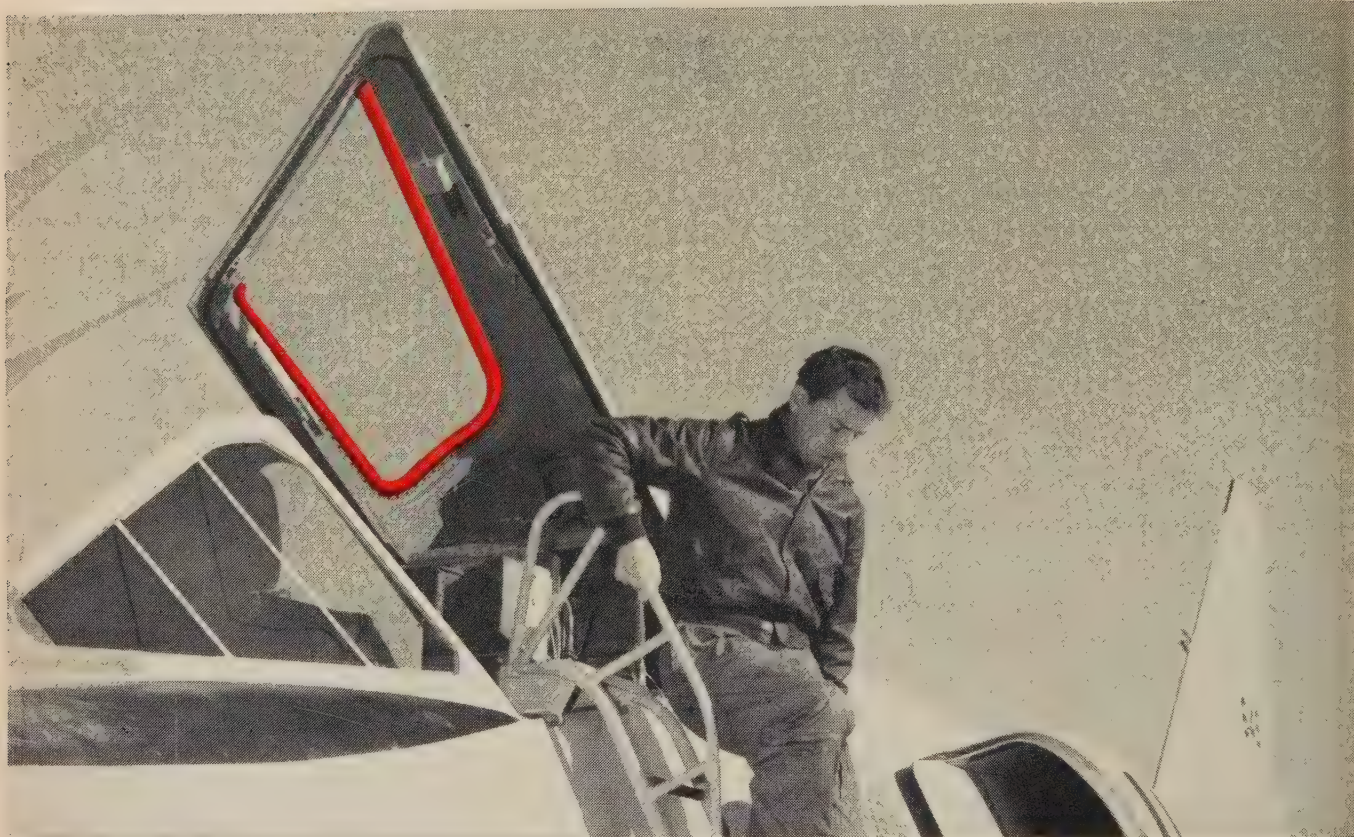
On the advance planning side of the picture, the quick change that is taking place in technology rules out any long-term rigid plans. NASA has been projecting a 10-year plan, but it is generally accepted that by the time the plan is written, it will be obsolescent. NASA is not on a fixed budget, and so its planning can be changed by political pressures, or by technical breakthroughs. There is no logic to a rigid program where technical change can redirect the entire course of an investigation.

In planning ahead, NASA calls for advance plans of the technical line staff—who obviously favor a major emphasis on their specific fields of investigation.

This line staff planning is done once a year, and is forwarded to the planning and evaluation group for review. If the staff planning is considered adequate, it is approved. If, as is mostly the case, the staff planning is weighed too heavily in favor of a specific line of in-

more on page 21

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*SHOWN: F-106 DELTA DART.

include potting of electronic gear and making of molds for prototype parts. Various consistencies are available for application methods other than caulking gun. For further information on this product, send for literature: "How To Use Silastic RTV." Address Dept. 0704.

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After Vulcanizing (24 hours at 77 F)	Fluid Grade	Caulking and Putty Grade
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Tensile Strength, psi ...	250 to 850	225 to 450
Elongation, percent	100 to 250	120 to 400
Brittle Point, degrees F ..	-100	-178 to -100
Shrink, linear, percent		
after 3 days* at 77 F	0.6	—
after 6 days* at 77 F	0.8	1.2 to 1.6
after 14 days* at 77 F	1.1	—
Water Absorption, percent after 70 hours immersion at 212 F...	1.0	1.0
Working Time	10 min. to 3 hr	2 to 5 hr

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SPACE/AERONAUTICS

vestigation, it is balanced off against other proposals. Finally the 10-year plan is formulated, but such a plan at best can only be a visual concept—the field is moving much too fast for a firm plan.

• • •

A new element has been added to the continuing Congressional and press criticism of President Eisenhower's defense policies, especially about the admitted missile gap. Some leaders in the defense industry are warning about shortsightedness, and even some Republicans with backgrounds in DOD are sounding off.

The most severe critic outside Congress has been Thomas G. Lanphier, Jr. After asserting that Mr. Eisenhower was taking "very dangerous chances" with the nation's survival, the Convair vice president was urged to tone down his criticism by Frank Pace, president of General Dynamics. The upshot was that Lanphier resigned his Convair post to continue his campaign.

His comments were followed by those of Dr. Leo Steg, manager of the Space Sciences Lab at GE's Missile & Space Vehicle Department. Steg called for "the bold, forceful individual leadership in our Government we have a right to expect—leadership which recognizes the inherent fallacy of just keeping up."

Pointing out that the missile gap could be closed by the expenditure of about \$4 billion, or less than one per cent of the gross national product, Steg asked, "Does the executive branch of our government feel that we will measure them primarily on their budget performance? . . . Let history not note that the most advanced civilization of this planet was lost for the sake of a balanced budget and lower taxes."

Statements by Robert A. Lov-

ett, a Republican and a former Defense Secretary, that the nation can and should spend more on defense did little to ease Mr. Eisenhower's anguish. Lovett repeated what he and other prominent Americans had written in the dust-gathering Gaither Report—that the Russian challenge is constantly getting stronger, and that the U.S. can afford to step up military expenditures without hurting the economy.

Despite all the criticism, the President's assertions that he knows more about the nation's defense needs than anyone else seemed to be having its effect on the public at large.

• • •

Industry spokesmen have been saying again that government contracting practices are destroying the incentive for doing business with the government. Companies have been shying away from too large a percentage of government work in their business mix.

Practices that discourage companies from doing business with the government include:

- tight procurement;
- multiple audits, first by the military procuring service, then by the Government Accounting Office, and then possibly by the Renegotiation Board;
- retention of patent rights by NASA;
- renegotiation;
- acquisition by the government of proprietary technical data and know-how.

In some of these areas, the government agencies recognize that industry disagrees with their procurement policies. However, they are bound by law and regulation to follow these practices—as in the case of renegotiation and of NASA's patent policies.

An up-to-date roster of people working in 33 major research

areas is being compiled by ARDC. The Cate program (Current ARDC Technical Efforts, pronounced Katy) will first list military officers and civilians at ARDC installations working in such areas as propulsion, flight control, communications, and biosciences. As the roster expands, it is expected to include people working under ARDC contracts at universities, Army and Navy facilities, and contractors' plants.

Contractors who consent to the listing of individual researchers by name will have the right to limit the distribution of these names. ARDC is planning to keep the roster current by mailing cards to the people on the roster every 90 days for verification and updating.

Cate already contains about 3000 names. The total probably will climb to well over the 100,000 mark as the program gets going.

Expected to be extremely helpful in preventing duplicating research, Cate's 33 scientific areas are each broken down into 6-10 technical areas. A number and a brief word description are used to pinpoint each researcher's specific field of study.

• • •

The Pentagon's deputy comptroller, John M. Sprague, concedes that "the U.S. economy today could support a larger defense program." But he maintains that that is not the real issue. He insists that the nation's "most important weapon is a balanced budget or, if at all possible, a budget surplus." Sprague, who has gone as far as any Administration official in admitting that budgetary considerations profoundly influence defense allocations, nevertheless insists that "staggering" sums have been invested in operational weapon systems.

CONNECT AND DISCONNECT ELECTRONIC COOLANT SYSTEM LINES

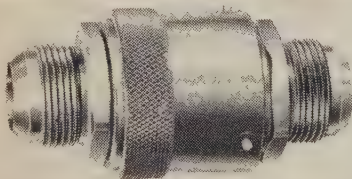
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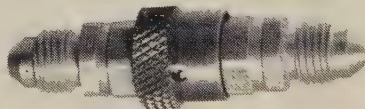
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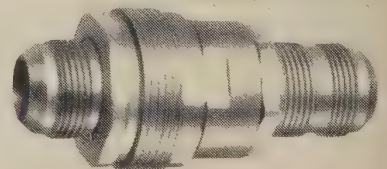
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SPACE/AERONAUTICS



technical management intelligence

How will Congress act on the defense budget?

THE TUMULT and the shouting over the fiscal '61 defense budget are far from over, but there are already definite signs showing how Congress will handle the problem. The President's defense program has become a political issue, and several presidential hopefuls are ready to campaign on a platform of "Not Enough for Defense."

Congress will boost several segments of the defense budget, even though the over-all total will not climb over the originally proposed \$41 billion. Whether or not the Administration will use the extra funds or impound them as in the past is anybody's guess. Mr. Eisenhower's statements that he knows more about the nation's defense needs than anyone else can mean only that the various programs will get just about what was asked for them in the first place.

IT IS REASONABLY clear that Congress will increase funds for the Zeus anti-missile system, the Mach 3 B-70, the solid propellant Minuteman ICBM, the Atlas ICBM (and perhaps also the Titan), and a B-52 air alert system. If current tests on the B-58 and Polaris systems prove out, there will be pressures to accelerate these projects as well.

Army wants to start pre-production on Zeus if tests succeed

AT WHITE SANDS, N.M., a Raytheon Hawk on January 25 successfully intercepted an Emerson Honest John ballistic missile. The Army immediately cited this effort as a "bullet-hit-bullet" intercept.

Sometime later this year, a Zeus will try to intercept and destroy IRBMs and ICBMs near the Johnston Islands in the Pacific. If these tests prove out, Army Chief of Staff Gen. Lyman L. Lemnitzer wants to start pre-production work on the anti-missile. This would require the \$137 million voted by Congress last year but withheld by the Budget Bureau.

ACCORDING TO Lt. Gen. Arthur D. Trudeau, the Army's R&D chief, the Zeus' booster and sustainer motors have been fired successfully, and the complete system will be ready for tests soon. Meanwhile, the former ABMA chief, retired Maj.

Gen. John B. Medaris, is calling for immediate production of the missile as "our only conceivable positive defense for the next 10 years."

More R&D money probably will be voted for the Zeus, but it won't be released by Budget until Dr. Herbert F. York, the Pentagon's director of research and engineering, is convinced the Zeus can really intercept Russian ICBMs.

AFTER HEARING Air Force Chief of Staff Gen. Thomas D. White testify how badly he wants the Mach 3 B-70 Valkyrie bomber retained as a production item (instead of two prototypes) in '63, Congress will undoubtedly increase the \$75 million allocated to the B-70 for '61. But as Sen. Clare Engle (D., Calif.) put it after predicting a boost for the B-70, "We have no way of preventing the Bureau of the Budget from simply impounding the money and stopping the program in its tracks." Rep. Carl Vinson, chairman of the House Armed Services Committee, also opposes the B-70 cutback—he says it increases the threat to U.S. survival.

NAA official gives estimates on costs of large orders for B-70

THE FIRST B-70 prototype is expected to cost \$400 million, but Jack J. Jones, B-70 weapon system manager at North American Aviation, believes the second will come to only \$40 million. He estimates the cost of a 50-plane wing, including prototypes and flight test aircraft, at \$3.3 billion, but adds that five B-70 wings could be had for \$6.5 billion. Jones says, "It is inconceivable to me that the U.S., in her current uncertainty over her defense future, would voluntarily abandon the one strategic weapon in which we clearly lead."

THE MINUTEMAN ICBM, which Congress and USAF both consider a great advance over the Atlas and Titan, has undergone at least six limited successful firings from underground silos to heights of several hundred feet at Edwards AFB, Calif. Lt. Gen. Bernard A. Schriever, commander of ARDC, says the first Minuteman will be operational late in '62, although actual squadrons to fire them will not be ready until the following year. Construction of the mobile railroad cars and underground bases to fire the solid ICBM will hold up squadron activation until that time.

more on next page



technical management intelligence

CONGRESS MAY go through the motions of voting an increase to accelerate Minuteman. However, USAF's present schedule is hard to speed up.

The Boeing-operated AF Plant 77 at Ogden, Utah, which will be used to assemble the Minuteman, will employ only about 50 people over the next 15 months. Maximum employment eventually will be about 800.

Navy is trying to get \$900 million for six extra Polaris subs

THE NAVY'S current program calls for three Polaris-firing nuclear submarines a year. Chief of Naval Operations Adm. Arleigh Burke is seeking DOD approval of a \$900 million supplemental appropriation for six more subs and the missiles for them. Burke believes that, if DOD and Congress act fast enough, 1-2 more subs could be available in '62 and 3-6 more in '63.

To date (and not counting the '61 budget), Congress has provided funds for 12 full Polaris subs and long-lead-time items for three more. Since '56, \$2.7 million has been spent on Polaris.

GEN. NATHAN F. TWINING, chairman of the Joint Chiefs of Staff, opposes any increase over the three-Polaris-a-year rate, claiming the JCS did not discuss an accelerated Polaris program in their talks on the '61 budget. The outlook on Polaris is more funds will be voted for the missile—and that no money will be released to the Navy unless the first operational subs equipped with the Polaris (and due late this year) proves so successful that a speed-up cannot be rejected.

Congress impressed by Power's plea for an air alert

RECOMMENDATIONS by SAC commander Gen. Thomas S. Power that the U.S. needs a constant B-52 air alert as long as the missile gap persists have made some impression on Congress. But the impression may not be strong enough to result in extra money, especially since Twining disagrees with Power.

Twining thinks the USAF should build up its ability to supply replacement parts for the B-52. He says this effort will cost only \$200 million over the next two years, as against \$2 billion that would be needed for a continuous air alert of B-52s. Twining also told Congress that if extra funds are voted for the constantly flying B-52

program, he would much rather use extra cash for the Polaris and Minuteman solid propellant deterrent missiles than for the B-52 air alert.

WITH THE CONVAIR ATLAS operational and the Martin Titan showing signs of shedding its bugs, there will be some calls for increasing the 13 Atlas and 14 Titan squadrons, which account for a total of 270 missiles (plus spares). Neither Martin-Denver nor Convair-San Diego is producing ICBMs at anything near capacity.

The widely publicized "missile gap" will cause some lawmakers to plead for greater output at San Diego and/or Denver. But, the AF logically points out, there is no point in producing more ICBMs if the bases and crews to fire them are non-existent.

Advanced B-58 foreseen if the B-70 cut stands

IF THE B-70 CUTBACK remains in force, the odds are good that USAF will buy an advanced version of the B-58 capable of all-supersonic cruise. The first operational Hustler-"C" squadrons could be ready by '63. They would bring the B-58 program to 116 aircraft and a cost of \$3 billion. The B-58C would use P&WA J58 engines instead of GE J79s. AF Under Secretary Dr. Joseph V. Charyk says the C seems attractive but warns that the AF will have to consider carefully how much redesign is needed.

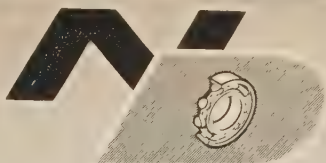
On the B-58 program, Congress will not even attempt to take any steps on its own—it will follow USAF's and DOD's lead.

ALL ATTEMPTS on Capitol Hill to increase the DOD budget will undoubtedly be balanced by cuts in some areas of defense and probably in foreign aid (military and civil) as well. By the time the defense money bill clears both houses in late June or July, the overall figure will not be much different from the \$41 billion sought in new obligational authority. And it is certain that the three services will spend and obligate only what the President and the Budget Bureau approve.

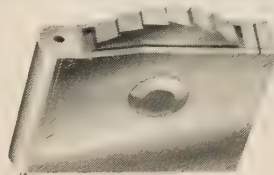
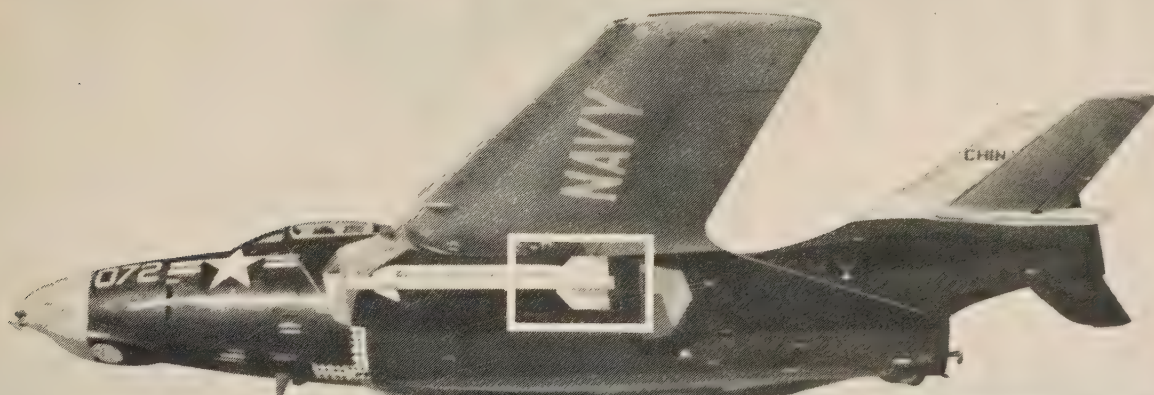
THE U.S. SPACE PROGRAM, set up as a two-headed monster, is coming under attack from all sides as almost unworkable. However, no two critics agree about whether NASA or DOD should monitor the overall project.

Maj. Gen. John B. Medaris, retired head of

more on page 26



CASE HISTORIES



N/D integral rolleron gyro wheel and shaft with precision instrument ball bearing solves sidewinder reliability problem. Actual ball bearing O.D. measures little more than an inch.

Designs Reliability Into Sidewinder Rollerons!

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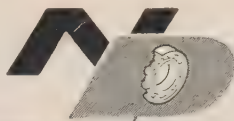
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technical management intelligence

ABMA, wants the U.S. space effort under control of the Defense Department. He maintains it is "illogical and incorrect" to let DOD and NASA pursue separate objectives. "Since no one authority is totally and immediately responsible for the complete mission, what is everybody's business ends up being nobody's business," he says.

JPL chief says NASA should get all space activities to prevent duplication

BUT DR. WILLIAM H. PICKERING, head of NASA's Jet Propulsion Lab at Caltech, is convinced NASA should get control over all space projects, including the Midas and Samos satellites. He points out that civil and military space programs must compete for scarce manpower, dollars, and facilities. He says unnecessary duplication and competition is resulting from the split-up. He also adds, "Most of the space weapon programs, if they are going to be weapon systems, are a long way off."

Hilliard W. Paige, general manager of GE's Missile & Space Vehicle Department, also proposed that our space efforts be merged. He emphasizes that "a fragmented program is self-defeating," and adds, "I would place the operational end of this program unequivocally under military . . . control."

MEANWHILE, the House Armed Services Committee, noting that the Advanced Research Projects Agency is now functioning as part of Dr. York's research and engineering office in the Pentagon, is recommending that the law that established ARPA be repealed.

An example of how ARPA now contributes to the confusion in our space effort was NASA's refusal to assume responsibility for Project Orion. This \$100,000-a-year ARPA project last year moved from a feasibility study of nuclear space propulsion engineering work. It now will probably be turned over to UASF.

Maneuverability of ramjet missiles is emphasized

USAF CHIEF OF STAFF Gen. Thomas White believes nuclear ramjet missiles will be important for our future military strength. Unlike ballistic missiles, he says, they will be able to weave, feint, and dodge while seeking out their targets. But

present programs are only in "proof of principle" status and far from the prototype stage, he says.

BRIG. GEN. IRVING L. BRANCH, of AEC's Aircraft Nuclear Propulsion Office, maintains that NASA's \$5.5 million contribution to nuclear propulsion studies in fiscal '61 is not enough. He claims the Project Rover nuclear rocket could be ready for flight in a few years, but will be delayed because ground tests are being postponed for a year because of Budget Bureau decisions.

AEC CHAIRMAN John A. McClone also says the Budget Bureau has withheld construction and operating funds on Project Rover. The Joint Congressional Atomic Energy Committee countered by recommending a speed-up in the program.

AF UNDER SECRETARY J. V. Charyk says the state of the art is still holding up the \$150,000,000-a-year nuclear aircraft propulsion program. The emphasis in fiscal '61 will be on the indirect-cycle propulsion system being developed by Pratt & Whitney Aircraft.

DOD is "actively considering" boosts in Polaris and Atlas programs

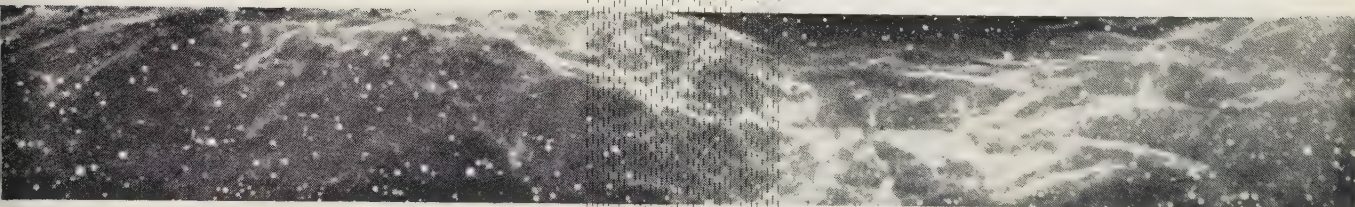
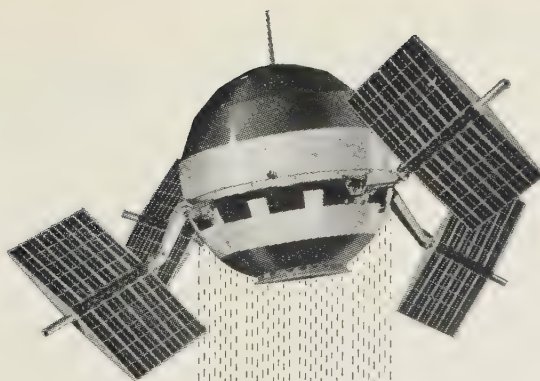
APPARENTLY STUNG by criticism of the U.S. missile gap, Defense Secretary Thomas S. Gates, Jr., is keeping the door open for increases in Navy and USAF ballistic missile programs. He says DOD is "actively considering" proposals to boost the number of Polaris submarines and available Atlas missiles by the end of '62, when the gap will be widest.

The Air Force now has approval for 13 Atlas squadrons but has indicated that no appropriation could speed activation of the overall number of squadrons. USAF's proposals to Gates involve increasing the number of Atlases in each squadron from 10 to 11 or 12.

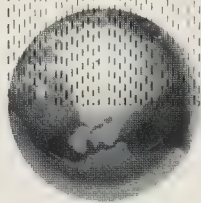
ADM. ARLEIGH A. BURKE, Chief of Naval Operations, has submitted plans for DOD approval to increase the number of Polaris-firing submarines.

The Army, which would also like additional funds for fiscal '61, has not made any pitch to Gates, mainly because it has been told there is little likelihood of any boosts.

Indications are that Gates and his advisors will make their decisions on Atlas and Polaris by June. If these missiles are boosted the President's planned balanced budget may go awry.



**Pioneer V
Paddlewheel Planetoid
Is Vaulting
Through Unexplored Space
Toward The
Orbital Path of Venus**



At this moment Pioneer V, one of the most advanced space probe vehicles ever launched, is on a course toward the path of Venus—26 million miles from earth. Blasted aloft March 11 by a Thor Able-4 rocket booster, this miniature space laboratory will reach its destination in about 130 days.

The project, carried out by Space Technology Laboratories for the National Aeronautics and Space Administration under the direction of the Air Force Ballistic Missile Division, may confirm or disprove long-standing theories of the fundamental nature of the solar system and space itself.

Energy from the sun—captured by almost 5,000 cells mounted in the four paddles—is used to supply all of the electrical power to operate the sophisticated array of instrumentation packed into the 94-pound spacecraft which measures only 26" in diameter.

By combining a phenomenal digital electronic brain (telebit) with a powerful radio transmitter inside the satellite, STL scientists and engineers expect to receive communications from Pioneer V at their command over interplanetary distances up to 50 million miles.

STL's technical staff brings to this space research the same talents which have provided over-all systems engineering and technical direction since 1954 to the Air Force missile programs including Atlas, Thor, Titan, Minuteman, and related space programs.

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industry viewpoint

by **Robert M. Loebelson**, Associate Editor

Who should pay for basic research?

EVERYONE in science and technology is giving lip service to the need for more basic research these days. But with all the hand-wringing about "scraping the bottom of the barrel of knowledge," no one is campaigning for basic studies in the same way that Admiral Hyman Rickover fought for the atomic submarine or Wernher von Braun agitated for space firings.

Those are the contentions of Welcome W. Bender, manager of Martin's Research Institute for Advanced Studies (RIAS) Division in Baltimore, Md. He maintains that total annual expenditures on basic research are running only about \$450-\$500 million ("less than farmers spend for seed"), or about 0.1 per cent of our gross national product.

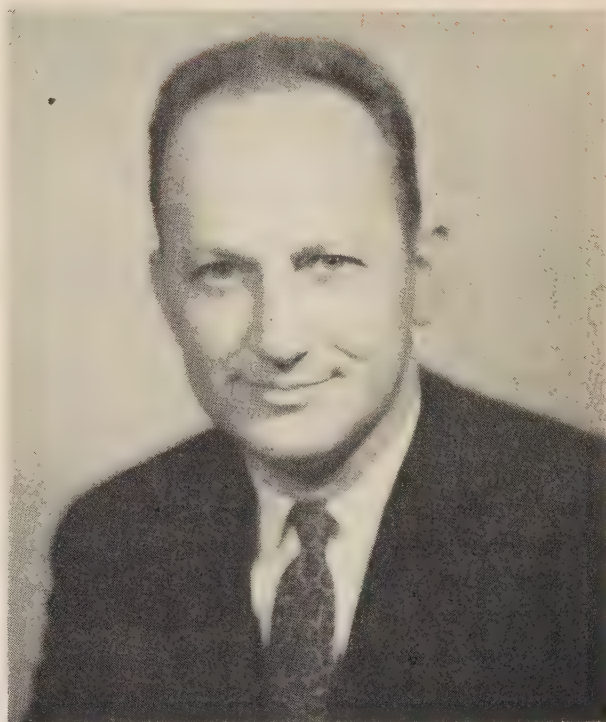
Bender believes national and corporate expenditures on basic science studies should be at least five and perhaps 10 times as high as they are now. "If we spent that kind of money," he says, "the U.S. could ultimately buy the finished products at lower cost."

Bender cites the example of nose cones for ballistic missiles. "If we had carried on more research on materials many years ago, missile nose cones would be even more advanced than they are now, and would cost the military services far less."

In a sense, says Bender, "basic research is a form of insurance. If we insure early enough and step up our basic research expenditures, we can keep total defense outlays from rising and maybe even turn them downward."

The Martin official takes issue with the Defense Department's attempts to have industrial organizations share the cost of basic research. "The military's policy is perfectly logical if it is tied to applied or product research. The services have a perfect right to expect risk capital to participate in applied research, whose results can be marketed by the firm doing the research."

"On the other hand," Bender adds, "the basic findings of one company may benefit a second con-



WELCOME W. BENDER, Manager, Research Institute for Advanced Studies Div., The Martin Co.

cern even more than they do the firm doing the research."

The RIAS executive is worried about the tendency of many companies and government agencies to save money by letting others do basic research. "If everyone took that attitude, our knowledge would soon be exhausted, and we would soon trail the Soviets in even more scientific areas."

Bender is firmly convinced that the federal and state governments—and even cities—should pay for the full cost of basic research, whether the studies are carried on by universities, non-profit organizations, or industrial firms. "Basic research benefits everyone, and everyone should share its cost," he says. He also objects to testimony before Congress by government officials who claim they are getting \$100 million worth of research for \$50 million. "The other \$50 million is still coming from somewhere—philanthropic contributions or company profits."

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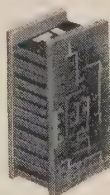
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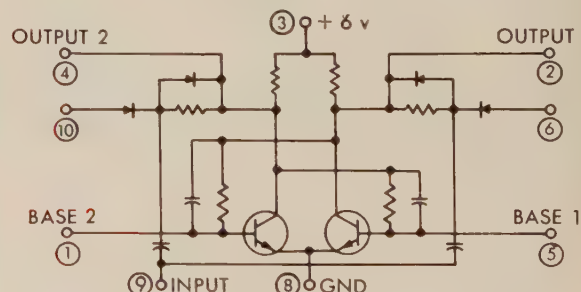
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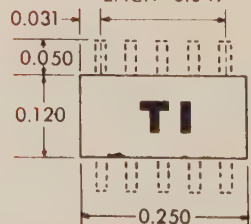


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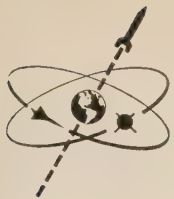
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aerospace engineering intelligence

Pioneer V to reach maximum communications range in five months

MISSION OF PIONEER V space vehicle is to explore interplanetary space out to about 50,000,000 miles communications range. Space Technology Lab scientists report that the 94.8-lb payload will enter a planetary orbit about the sun. It will take about five months for Pioneer V to reach the maximum range at which communication is possible.

Received data show that the temperature inside the payload is being held to 30-80 deg F. Heat generated by electronics is absorbed by lithium heat sinks which radiate the heat into space. The payload is also coated to balance the absorptivity and emissivity of solar energy and keep the temperature within a narrow range.

SCIENTIFIC FINDINGS transmitted to earth stations will probably take about 3-4 weeks to process. The vehicle is expected to collect information on radiation, magnetic fields, and micrometeorite density.

Pioneer V has been beaming back data with a five-watt transmitter. In 3-4 weeks, it is reported, a 150-W transmitter will be put into operation.

Broad temperature range for solid propellant claimed by Grand Central

MAJOR PROPELLANT breakthrough is claimed by Grand Central Rocket. For years, says the company, the propellants industry has been trying to develop a high energy solid propellant that could stand a broad range of temperature extremes. Now it's been done. Grand Central has taken a completely case-bonded, cast-in-place grain of nitrasol propellant, temperature-cycled it repeatedly from -75 to +165 deg F, and then fired it at -68 deg F.

XLR-99-RM-1 ENGINE for X-15 aircraft successfully passed its pre-flight rating test program. This is a big step in rocket engine development, says Thiokol, because it signifies that the U. S. now has a fully throttleable rocket engine that can be used for manned flight. Big development problem was to design for smooth control of the continuously variable thrust and in-flight start-stop-restart operation.

ROLLS-ROYCE in England developed a new bypass engine aimed at the medium range civil aircraft market. The RB-141 has a 15,000 lb thrust. A scaled-down version, the RB 163, has 10,100 lb thrust and an increased bypass ratio.

Rolls-Royce does not favor bypass ratios as high as those Bristol Siddeley is using, but acknowledged to SPACE/AERONAUTICS there is a tendency for the ratios to creep up. It sees the choice of bypass ratio as depending on the balance between outside diameter (pod drag), installed weight, and the need for thrust reversers on the one hand and noise and specific fuel consumption on the other. Rolls-Royce believes a ratio of 0.7 is best at present; Bristol's optimum is said to be 1.5.

Narrow delta and jet lift are favored by British airliner designers

ADVANCED PLANNING group at Rolls-Royce, which did the preliminary engineering on the bypass engine, is now working on supersonic airliners and jet lift aircraft. It now favors a narrow-delta supersonic design with jet lift. A light alloy skin would carry local loads only; the main loading would be taken up by an internal girder structure shielded against aerodynamic heating.

At the same time, advanced planning group engineers are also working on the development of a blind landing system with linked throttle and radio altimeter.

HOVERCRAFT VEHICLE built and tested by Saunders-Roe may be followed by a larger design. Main problems of the prototype are low speed maneuvering over land and the suppression of dust and spray. The new model would have better performance and better operating economy.

BLACK KNIGHT'S success in five consecutive launchings is attributed largely to the automatic sequencing system used in the prelaunch countdown. The sequence patchboard has 40 channels in pairs, each of which is selectively controlled. No channel can operate unless its predecessor has functioned correctly.

WATER ELECTROLYSIS has been proposed as a means of generating oxygen for manned spacecraft. As described by John F. Foster, of Battelle

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aerospace engineering intelligence

Memorial Institute, at a meeting of the American Institute of Chemical Engineers, the first step would be to convert gaseous carbon dioxide into solid carbon and water by reducing the carbon dioxide with hydrogen. Next step would be to pass electric current through the water, so that the water dissociates into hydrogen and oxygen.

For long space trips, Foster says, the process appears to be substantially superior to other schemes under consideration. He pointed out that on trips lasting several years, it will be impossible to carry the necessary oxygen. The electrolysis system would be one answer. According to Foster, it offers low weight, great reliability, and good efficiency. It would also have a low energy consumption, he claimed.

GE hybrid rocket of several years ago still looks good today

HYBRID ROCKET development is getting renewed attention. Some years ago, the General Electric rocket group at Malta, N.Y., developed a test motor whose simplicity has much to recommend it today. The motor consisted of a liner of polyethylene mated to a rocket chamber. Decomposed and concentrated (90 per cent) hydrogen peroxide was injected into one end of the chamber. Upon entering the combustion chamber, the peroxide products reacted with the polyethylene to increase the chamber temperature and pressure.

The scheme combined the simplicity and high propellant loading density of a solid rocket with the good impulse, start-stop-start operation, and throttleability of a liquid. Controls were needed only to maintain pressure in a single feed line and a tank and for the flow of the peroxide supply.

ROCKET CLUSTERING still looks like a good, cheap way of boosting takeoff thrust. For instance, four Minuteman or Sergeant solid rockets clustered around an Atlas can stretch any given space mission by 20 per cent at 60 per cent less than the cost of a new liquid booster. The structure of the mother rocket has to be modified, but this is not considered a big problem.

RECENT INTEREST in hybrid engines has been shown by the Navy and Army. They are asking for design studies on hybrids to be used for Jato and certain carrier takeoff situations. It is almost certain that newer designs would be fueled by liquids with higher energy than peroxide.

LIGHT REFRACTION technique for detecting wing icing was developed by a team of physicists at Armour Research. Two translucent plastic rods are mounted in the wing parallel to each other and a fraction of an inch apart. A light is beamed into one rod. When ice forms between the two, the light refracts out of the first rod, in which it is usually trapped. The light passes through the ice and into the second rod to activate an electric-eye warning system. The thicker the ice, the more light is refracted and the greater the current produced by the electric-eye cell.

THE "ATLANTIC" was picked by NATO as a patrol bomber. A replacement for the Lockheed Neptune, the midwing plane is to be powered by two Rolls-Royce Tyne turboprops, each putting out more than 6000 ehp. Wing span will be 124 ft, length about 90 ft, and height about 35 ft.

The Atlantic will carry the latest anti-submarine equipment, will have a crew of 12, and be able to stay in the air for 12 hours. Cruising speed will be around 400 mph.

Plans are to start production of 100-200 planes. Deliveries are to begin in late '63 or early '64. Several European firms will cooperate in the production program.

Vanguard rocket run for over 2000 seconds in twelve firings

ADVANCED VERSION of the first-stage Vanguard engine completed the testing phase of its PFRT (preliminary flight rating test). This X405H engine was originally developed by General Electric to power the second stage of the now shelved Vega space vehicle. NASA decided to carry the development through the PFRT phase so it would have a fully qualified space engine in its inventory in any case.

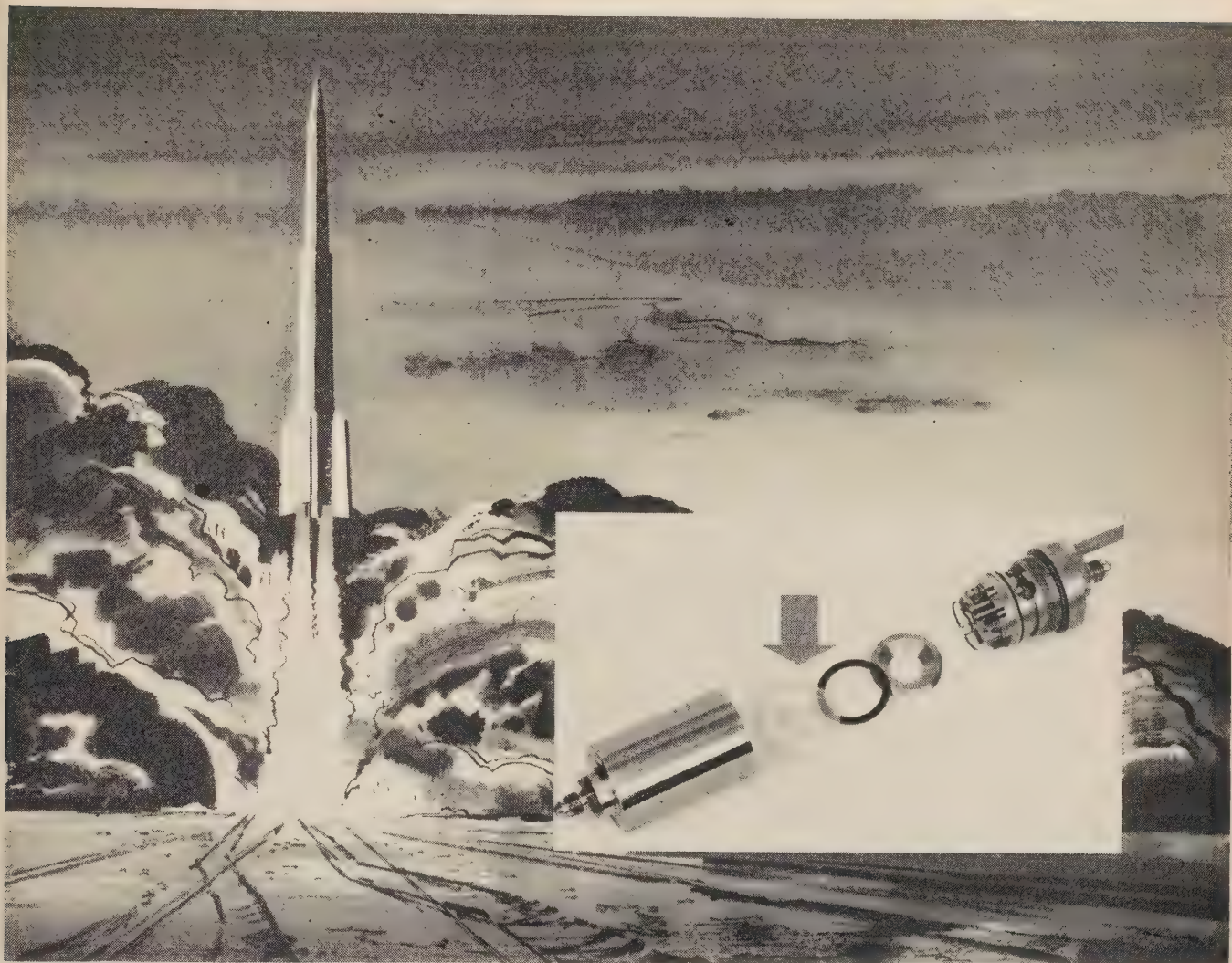
In the test, the X405H was operated for over 2000 seconds in 12 consecutive static firings without component change or repair. Tests included shutdown, simulated coast periods, and restart.

FIBER-OPTIC device has been developed for instant detection of aircraft engine fires. Fiber optics are hair-like threads of glass. In the fire detection application, a bundle of optical fibers runs from the aircraft engine compartment to an electronic signal activating unit. The fire detection system is triggered by light transmitted through

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the fibers. Pyrotector, of Hingham, Mass., worked with the Optical Co. of Southbridge, Mass., to develop the system.

PERSHING MOTOR used in the Army's first test flight was a conventional design. According to Thiokol, new motors, now under development, will be used in later flights. These improved designs will reflect advances in propellants and use higher performance metal and plastic components, says Thiokol.

VANDENBERG AFB, Calif., missile complex was shown to the press for the first time. Included in the tour was the checkout station for incoming Atlas missiles. Every missile must pass an acceptance test, including a final IBM-type, card-operated APCHE (Automatic Programed CHECKout Equipment) station. The cards program in pressure checks, timing checks, etc.

The average checkout per card can take as long as 314 hr or as little as five minutes. The first inspection can take as long as 2-3 weeks before faults caused in transport are found. After the missiles have been in launch position for six months, they must be returned for an APCHE 180-day recycle test, which can take from 20 to over 30 days.

Checking out Agena usually takes 30 days

AGENA-THOR Discoverer vehicle was also undergoing checkout at Vandenberg's R&D emplacement. SAC officers stated the checkout of the Agena usually takes about 30 days.

The Agena separates through the action of two retro-rockets on the sides of the adapter structure that connects the Agena with the Thor. After the retro-rockets fire, explosive bolts actuate.

IN THE AGENA PROGRAM, SAC stated, design changes are worked on the principle of concurrency. If telemetry shows a malfunction during a flight, researchers go back and completely recheck the system and components and rework the design. Malfunction data are immediately fed back into design, production, etc., so that changes are worked right into next vehicle.

MECHANICAL PROBLEMS in Discoverer firings have tended to be with the GSE rather than the vehicle, it was stated. In the first eight launches, all airborne systems worked well.

Changes have been made at launch site to speed

up the program. For instance, in the first launch, pyramid-shaped flame deflectors on the vernier engines shot flames at launch cables and fired them. On subsequent models, bucket-shaped deflectors were used.

In later launches, a blue flame shot back through an open air conditioning duct to burn cables in the pit clear back to the electric trailer. Since then, a stove-type damper has been put on the duct that closes if hit by gases, the cable trench has been filled with sand and wetted down; and the cables have been covered with layers of metal foil and fiberglass.

Titan's storage silo goes down 155 feet

FIRST SEMI-HARDENED underground Titan launch site is nearing completion at Vandenberg. Five such sites are planned for the base.

Depth of silo is 155 ft, at a diameter of about 35 ft. The missile will be lowered into the silo by a standard Coles crane with special slings. The missile launch platform and flame bucket sit on an elevator, which lifts the missile to the surface for firing. Two hydraulically operated cast-concrete doors, each of which weighs 280 tons and has special carbon steel hinges, weighing nine tons, cover the top of the silo. All the steel structure in the silo crib also is of special carbon steel (with increased silicon content).

CONTROL AND EQUIPMENT terminal, also located underground, has five levels and is separated from the silo by 20 ft of concrete. From the bottom up, these levels are:

- AMF power pack and logic or switching racks for launcher operation;
- air conditioning and hydraulic power pack with three 3000-psi lines;
- checkout gear;
- power distribution center (4160V);
- instrumentation (used for test sites only).

ALSO UNDER CONSTRUCTION at Vandenberg is the first Atlas underground silo, which will have a depth of 174 ft.

NOVA BOOSTER was described by A. Hyatt, NASA's assistant director of propulsion. It will carry six 1,500,000-lb thrust Rocketdyne F-1 engines and will be 220 ft tall on the launch pad and 44 ft in diameter. Propellants will be RP-1 and LOX.

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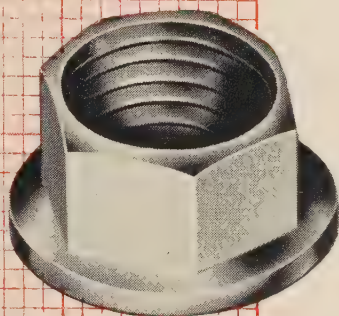
Again...

ESNA

gives the design decision to the engineer

If your major consideration is...

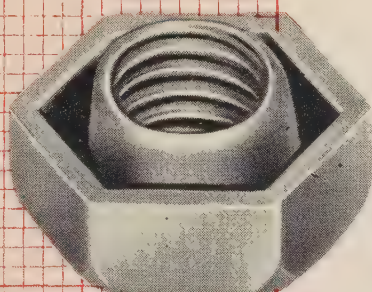
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THIS NEW DESIGN is ESNA's recommendation for applications where space and weight reduction are primary needs. Meets MIL-N-25027; reduced wrenching dimensions permit more efficient center-line bolt design; wrench heights carefully engineered to assure satisfactory assembly line performance. Materials: carbon steel, AMS6304 alloy steel and A286 stainless steel.

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NAS679	.9	1.7	2.4	2.6	4.6	6.4	8.6	140,000 psi
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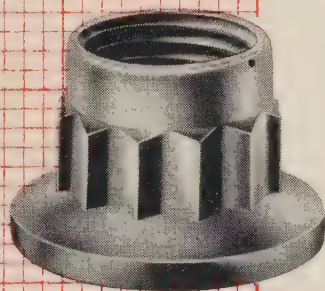
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This complete line of low-height, lightweight NAS 679 hex nuts has been designed and produced to ESNA's exacting quality standards. Qualified to MIL-N-25027. External-internal wrenching surfaces for easy installation in limited access areas. Sizes 4-40 through 7/16-20. Alloy steel for temperatures to 550°F; A286 stainless steel for temperatures to 900°F and nonmagnetic applications.

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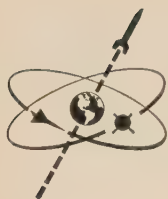
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aerospace engineering intelligence

The Nova, Hyatt said, will be able to place 290,000 lb in a 300-mile orbit, lift a 60,000-lb satellite into a 24-hr orbit; or send a 100,000-lb vehicle to the moon.

Total of six Atlas sites at Vandenberg

PRESENT VANDENBERG SAC SETUP includes three operation "soft" Atlas positions and three horizontal Atlas positions, in which the Atlas can be lowered until it lies on its side. Three other horizontal Atlas positions are under construction. Also completed are seven Thor IRBM positions.

In the horizontal Atlas setup, SAC officers stated, the launch of a missile will damage GSE cabling, the launch mount, etc., and require repairs before next missile can be launched. With special repair kits, it is claimed, the sides should be fixed up in two days.

GO-AHEAD FOR SKYBOLT ALBM was given to Douglas by USAF on the basis of a complete design study and feasibility tests. The two-stage, solid propellant vehicle will develop hypersonic speeds over ranges of up to 1000 miles.

TWO GE CJ-805-23 TURBOFAN engines carried a leased USAF RB-66 aloft for 1 hr, 40 min. The new engine is slated to power the Convair 600 in '61, putting out 16,100 lb thrust. GE officials claim the use of an aft-fan increases takeoff thrust by 44 per cent, cuts cruise SFC by 12-15 per cent, and provides a 5:1 power weight ratio.

Stress corrosion strength up for Al-Mg alloys

NEW TEMPERING process for Al-Mg alloys increases the stress corrosion resistance of 5456 and 5083, reports Alcoa. High properties were previously obtained by cold working to the -H32 and -H34 tempers, which increased the alloys' susceptibility to stress corrosion.

The new -H323 and -H343 tempers improve the resistance to stress corrosion without sacrificing cold-worked properties, Alcoa says. Minimum strengths include:

- -H323 (0.126-0.249)—45 ksi TS, 34 ksi YS, and eight per cent elongation for 5083; 48 ksi TS, 36 ksi YS, and eight per cent elongation for 5456;
- -H343 (0.126-0.249)—50 ksi TS, 39 ksi YS, and eight per cent elongation for 5083; 53 ksi TS, 41 ksi YS, and eight per cent elongation for 5456.

THIRD-SCALE MINUTEMAN firings from simulated underground silos will save a lot of money and time (USAF reports). The program was needed because the Minuteman must be ignited and launched while inside its silo, and data on such an operation were meager.

In the test series at Edwards AFB, Calif., a horizontal silo of ¼-in. thick AISI 1020 steel plate, is used. One end of the silo is closed by a ¾-1½-in. thick, movable steel flame deflector plate. Steel girders anchor the tube in a 33x58-ft concrete pad. An overhead metal track from the open end of the silo to a lab van is used for moving the third-scale missile into position. Six ½-in. holes around the center of the flame deflector are used to spray 240 gpm of water at 150 psig into the silo at burnout.

Final guidelines for full Minuteman tests

THE MISSILE'S first-stage skin is ¼ in. thick—much heavier than that of the actual Minuteman. An Atlantic Research cluster of four solid propellant rockets is used for the first stage. The second and third stages are battleship versions in same general shape as the missile's but are heavily instrumented.

Pressure, temperature, acceleration, vibration, and acoustic and thermal radiation are among the parameters under study. USAF expects the program to provide final guidelines for the full-scale Canaveral test launch sites. Present setup is partly based on earlier ½-scale and 2.75-in.-solid propellant rocket tests run by USAF and Boeing.

ADVANTAGES of die design with hydraulic pad pressure were described to American Society of Tool & Manufacturing Engineers seminar by C. A. Barrett, of Die-Draulic Grip. Springs, rubber, and other media, he noted, progressively build up pressure. A hydraulic system metering oil confined in small cylinders, on the other hand, offers not only full pressure from the beginning of the pad movement, but also infinite pressure control from zero to system capacity, he stated.

Hydraulics, Barrett said, eliminates the metal wrinkling that can occur with conventional die pad holding methods because of insufficient pressure at start. An example of the use of the hydraulic approach, said Barrett, is the forming of corrugations in a strip. In this case, the pressure is arranged so that the stock is pulled from each end as each bead is formed in staggered rotation. Twenty-four two-inch-diameter pistons with a maximum pressure of 377,016 lb are used.

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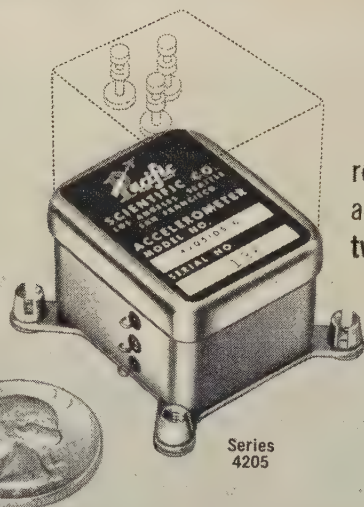
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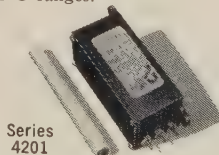
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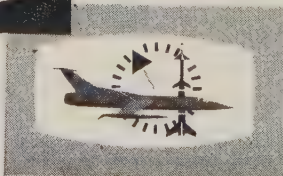
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April 5-8—National Aeronautic Meeting & Missiles & Aircraft Engineering Display, Society of Automotive Engineers, Commodore Hotel, N.Y.C.

April 6-8—Structural Design of Space Vehicles Conf., American Rocket Society's Structures & Materials Committee.

April 11-13—Electrical Engineering in Space Technology, American Institute of Electrical Engineers, Hotel Baker, Dallas, Tex.

April 12-13—Technical Conf., Institute of Radio Engineers in conjunction with ARS, Hotel Alms, Cincinnati, Ohio.

April 18-19—Joint Conf. on Automatic Techniques, ASME, Sheraton Hotel, Cleveland, Ohio.

April 19-21—International Symposium on Active Networks & Feedback Systems, Polytechnic Institute of Brooklyn; Dept. of Defense Research Agencies; IRE, New York City.

April 20-22—Symposium on Manned Space Stations, Institute of Aeronautical Sciences; NASA; the Rand Corp., Ambassador Hotel, Los Angeles, Calif.

April 20-22—Fluorocarbons Division Meeting, Society of the Plastics Industry, Hotel Roosevelt, New Orleans, La.

April 21—Eastern Regional Meeting, Institute of Navigation, Key Bridge Marriott Motor Hotel, Washington, D. C.

April 21-22—Heat Transfer Conf., "A Survey of Radiation Phenomena and Heat Transfer Equipment for Space Flight Application," Oklahoma State University, Okla.

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April 21-22—Southwest Metals & Minerals Conf., "Metals and Materials for the Space Age," American Institute of Mining, Metallurgical and Petroleum Engineers, Ambassador Hotel, Los Angeles, Calif.

April 21-28—Ultra High Speed Machining and Explosive or High Energy Forming, American Society of Tool Engineers; Air Materiel Command Aeronautical Systems Center, Detroit, Mich.

April 25-26—Canadian Section Conf., SPI, London Hotel, London, Ont., Canada.

April 25-26—Western State Section/The Combustion Institute, Lockheed Aircraft Corp., Palo Alto, Calif.

April 25-29—Metals Engineering Division—AWS Conf., ASME, Biltmore Hotel, Los Angeles, Calif.

April 25-29—Wind Tunnel & Model Testing Panel: Boundary Layer Research, The Advisory Group for Aeronautical Research & Development, London, England.

April 25-29—41st Annual Convention and Welding Exposition, American Welding Society, Biltmore Hotel, Los Angeles, Calif.

April 27-28—National Meeting on Space Age Materials, Cincinnati Chapter of ASM, Sheraton Gibson Hotel, Cincinnati, Ohio.

April 28-29—Symposium on "Closed Circuit Respiratory Systems," Wright Air Development Div., Wright Patterson AFB, Ohio.

May 9-13—Second Southwestern Metal Exposition and Congress, ASM, State Fair Park, Automobile Bldg., Dallas, Texas.

August 15-20—11th Annual Congress, International Astronautical Federation, Royal Institute of Technology, Stockholm, Sweden.

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April 1960

Engineering notes from the SMI REPORTER

BY STANLEY M. INGERSOLL, *Capabilities Engineer*



Report No. 4

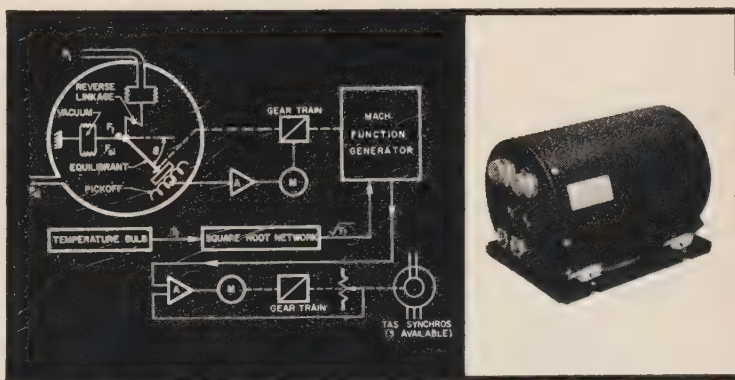
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Typical Performance Specifications

TYPE NO.	TRUE AIRSPEED RANGE (KNOTS)	ALTITUDE (FT.)	ACCURACY (KNOTS)
AXC 620	70 — 450	0 — 20,000	± 4%
	70 — 125	0 — 20,000	± 1%
	125 — 450	0 — 12,000	± 2%
	125 — 450	12,000 — 20,000	± 2%
AXC 620-1	100 — 200	0 — 10,000	± 3%
AXC 620-2	300 — 1500	0 — 80,000	± 12

NOTE: These are standard accuracies. Increased accuracies are available over restricted ranges upon request, and special ranges and output forms are also available. AXC 620 and AXC 620-1 are capable of operation up to 40,000 ft. with reduced accuracies.



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For more information and complete operating specifications, write or wire SMI today. Address your inquiry to Stanley M. Ingersoll, Capabilities Engineer.

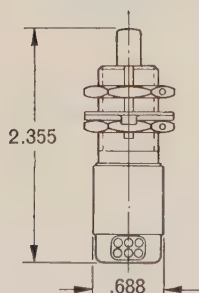
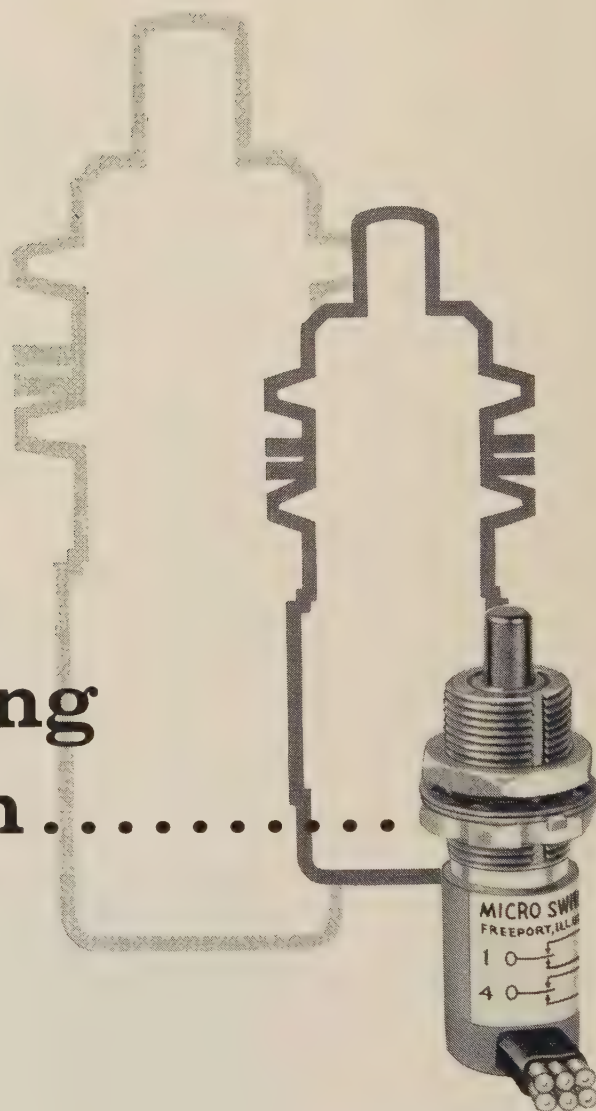


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7 amperes; inductive, 4 amperes.

New 402EN—smallest two-circuit sealed environment-free switch available

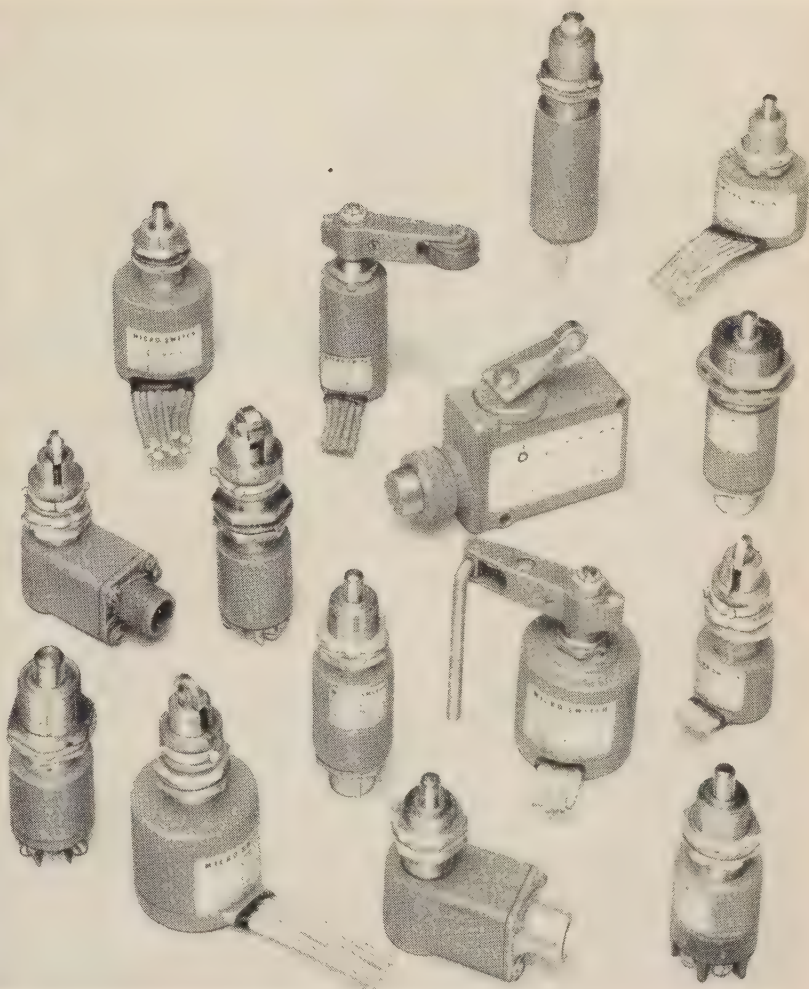
The new reduced diameter of the MICRO SWITCH 402EN makes it possible to "tighten up a notch" on component designs, save both space and weight. This plunger-actuated sealed environment-free switch contains two sub-subminiature basic switches, for two single-pole double-throw circuits—yet measures only .688" in diameter.

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MICRO SWITCH Precision Switches

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Basic research:

low man on NASA totem pole

Everyone in and out of government pays lip service to the need for basic research. But how much is actually being done? This article begins a new S/A series on the scope of basic aerospace research, the approaches government and industry are taking in this area, and the money they are spending.

by Robert M. Loebelson, Associate Editor

BASIC RESEARCH, according to the definition in the President's budget message, has as its purpose "increasing the fundamental scientific knowledge that underlies the nation's research and development and its technical progress." The President estimates the government will spend more than \$600 million on basic research in fiscal 1961, as against about \$500 million in the current fiscal year.

The National Aeronautics and Space Administration's 1961 budget also has a \$600 million R&D figure—\$503 million for R&D work and \$97 million for new R&D facilities. But only a small fraction of this total will go for "increasing fundamental scientific knowledge." This is true even though NASA and its predecessor, the National Advisory Committee for Aeronautics, have traditionally been considered the government that handles the bulk of basic research in the aerospace field.

According to NASA's director of advanced research programs, Ira H. Abbott, his agency's advanced research activities include:

- "Objective" research to provide the technical background for the exploration and use of space.
- The use of research findings as the basis for new advanced concepts for future space missions.
- Research assistance to insure the prompt and ef-

fective application of research results by NASA, DOD, and others.

As examples of NASA's "objective" research, Abbott cites the X-15 program, the blunt-body studies that led to ballistic missile nose cones and Project Mercury, and the work leading to Dyna-Soar. He explains that NASA's objective research program is designed to "seek out the technical problems where sufficient knowledge does not exist to permit practical engineering solutions."

In fiscal 1961, NASA will have about 7800 people working on advanced research under Abbott, while Dr. Abe Silverstein's group, which will work on payloads, will number about 500, and so will Brig. Gen. Don R. Ostrander's propulsion group (which includes the Von Braun team at Redstone Arsenal). However, NASA's allocation for lab research will run to only about \$90 million in this fiscal year and top \$100 million by fiscal 1962.

Abbott finds no real fault with this distribution of funds, which was decided on by NASA Administrator T. Keith Glennan. "Dr. Glennan has to show Congress results and that's why so much of the NASA budget is going for boosters and payloads," Ames says. But the fact remains that only about 10-12 per cent of NASA's total budget, or about \$31 million, is going for lab-type research. An additional \$4-5 million in basic research contracts is being awarded to universities and other non-profit research organizations.

NASA now is emphasizing space R&D

NASA today is emphasizing space R&D (65 per cent) and is paying less attention to aeronautical R&D (35 per cent)—in both basic and applied work. Milton B. Ames, Abbott's deputy, further foresees the possibility that only 25 per cent of NASA's research activities will be devoted to aeronautics in the relatively near future.

There are many people in the military services and in industry who complain that NASA is not doing the kind of research it ought to do. In reply, Ames contends that "NASA is just as interested in the industry's problems as NACA ever was."

One point stands out in NASA's attitude toward genuinely "basic" research: NASA "simply does not have enough money" as one spokesman put it, "to pursue studies in the blind hope that something will come of them."

Of course, if you interpret the word "basic" liberally, you can easily conclude that NASA is doing more basic research than did NACA. During the NACA days, the agency's budget, at least as far as the labs at Langley, Va., Cleveland, Ohio (Lewis), Moffett Field, Calif. (Ames), and Wallops Island, Va., were concerned, allowed 67 per cent for applied research, 10 per cent for specific research, and 23 per cent for basic research. Today, basic research accounts for 31 per cent of the work at the NASA labs, while applied research accounts for 52 per cent, and specific research for 17 per cent. ("Specific research" work in support of NASA and DOD activities includes projects like Scout, Mercury, the astronomical satellite, and space ferries.)

One area in which NASA can truly be considered to be doing basic work is the agency's research grants and contracts program. Climbing from \$3 million in fiscal 1959 to nearly \$5 million this year, and programed for \$10 million in fiscal 1961, this effort involves relatively small awards (averaging \$75-100,000) to schools and similar groups for something akin to basic research.

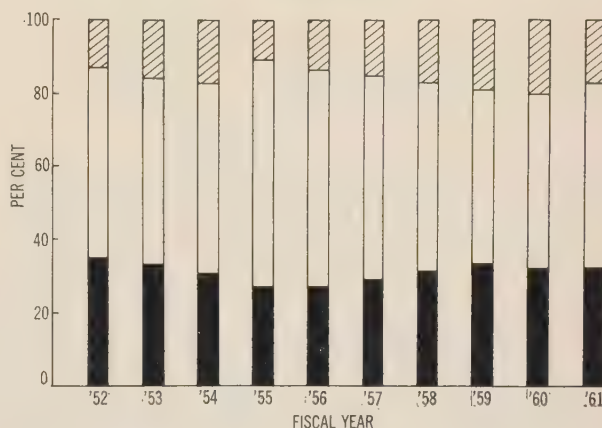
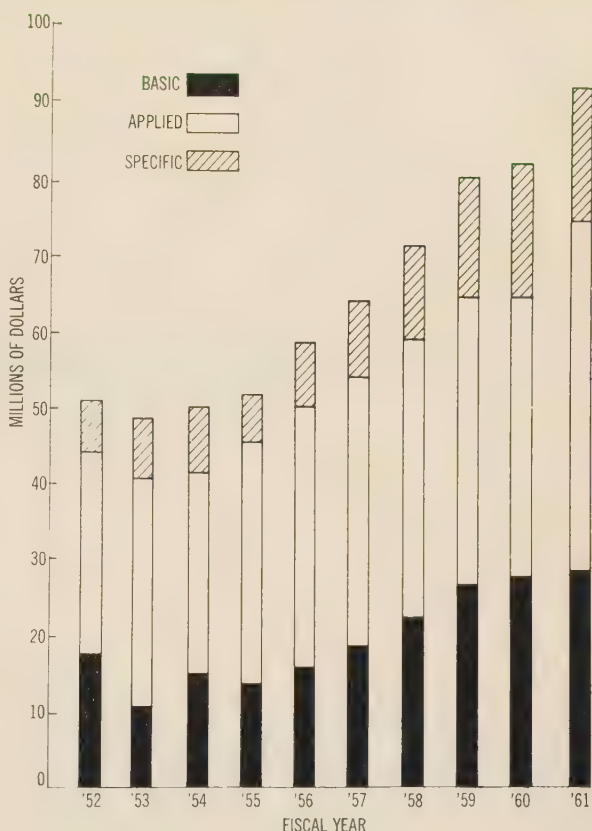
No risk of contract duplication

Among the contracts administered by Dr. Lloyd Wood's Office of Research Grants and Contracts are:

- \$110,000 award to Yale University for studies of molecular beam frequency standards and atomic collision cross-sections;
- \$50,000 contract to the Bureau of Standards for studies of the transition from laminar to turbulent flow in boundary layers under subsonic and supersonic conditions;
- \$150,000 contract to the Naval Research Laboratory for studies of the radioactivity of the moon by means of anti-coincidence gamma and beta counters;
- a \$39,500 contract to Marlin Rockwell for studies of methods for reducing the amount of end fiber in bearing components;
- a \$15,000 contract to Franklin Institute for research on gas-lubricated bearings.

NASA claims its current research awards to outside organizations cannot duplicate the contracts made by other U.S. agencies because of continuing personal contact and coordination between NASA officials and representatives of the Bureau of Standards, the Bureau of Naval Weapons, the Army, the Office of Naval Research, AF's Office of Scientific Research, and other research-contract-awarding groups. As Milton Ames puts it, "We've come a long way from the days just after World War II, when the prevailing attitude was that basic research was sacrosanct and it really didn't matter how many times a group got paid for its studies."

Although NASA's research work at Langley, Ames, and Lewis has touched on various basic study programs, the agency's activities in the space field have pointed up how much more remains to be done. Dr. Hugh L. Dryden, NASA's deputy administrator, explains that "experience has made us more acutely aware of the unknown factors in the conduct of R&D



TREND of NASA research expenditures since 1952. Data for fiscal 1960 and 1961 are estimated.

on the previously unexplored frontiers of space. The course ahead for several years is well established, and we have made plans for a decade ahead in the light of our present knowledge." This 10-year program, Dryden notes, will be revised and modified as new information becomes available.

NACA and NASA research on the use of liquid hydrogen (dating back to 1949) has led directly to the upper-stage high-energy Centaur engine now under development. Dr. Glennan, Dr. Dryden, and their associates hope that current objective research will prove equally beneficial to the nation's military and civil aerospace programs.—End

Ion rockets

give top specific impulse

This is the second article in a three-part series on electric propulsion. Last month's article covered plasma rockets; next month arc-jet and photon engines will be reviewed.

by Kurt R. Stehling, Contributing Technical Editor

THE ION ENGINE is built around an ion-producing chamber, in which a working fluid is electrically charged by ionization—at least one electron is removed from each atom of the fluid, which is usually monomolecular (*Fig. 1*). The remaining ions then are electrostatically accelerated and exhausted, so that they exert a thrust on the vehicle carrying the ion engine.

The electrons tend to recombine with the ions from which they have been separated and must therefore be diverted from the ion stream. As an electric current, for instance, they could bypass the ion accelerator.

Electrons reappear at the point at which the accelerated ions leave the engine. If they were not added to the ion stream at this stage, the ion-propelled vehicle would be electrically unbalanced. The injection of electrons also is necessary for maintaining the proper space charge (the measure of the number of particles of like charge in a given volume).

It is of course possible to accelerate both ions and electrons in an electrostatic field, but then you get a plasma engine. Actually, plasma engines for practical reasons use magnetic rather than electrostatic acceleration.

Electrically and even mechanically, the ion engine is simple. Electrode design, for example, is not as complicated as for the plasma engine. Naturally that doesn't mean that there are no problems.

The design problems begin with the choice of working fluid. This fluid must be easily ionized and yet have good density and storability under space conditions. Its cost is not too important, since most applications of ion propulsion that we can foresee involve very low thrust levels.

Among the fluids that come into consideration, cesium is outstandingly qualified. It requires the least electric power for single-stage, or one-electron, ionization, and apparently it would not be affected by space temperatures and radiations.

If cesium is used, how is it to be fed to the ionizing emitter? It is possible to liquefy cesium in an electric boiler, vaporize it, and pass the vapor through a heated, porous metal plug or across a heated emitting surface (*Fig. 2*). Hollow tungsten or platinum filaments have also been proposed. The liquefied cesium would flow through them and then be diffused through their white-hot surfaces.

A major problem in the design of the ion generator is that this unit must produce a copious flow of charged particles without excessive heating and erosion, or sputtering, of its surfaces. Tungsten, tantalum, and other metals have been proposed as suitable emitter materials under these circumstances, and metal-ceramics are also in the running. In any case, it should be possible to get thousands of hours of operation regardless of the sputtering effect of even a "heavy" ion beam current (of about $\frac{1}{2}$ amp). Heat transfer from the ion generator poses another problem and may require the use of insulation.

We are not much further along on the design of the ion accelerator, or gun. Parallel plates, successive acceleration and deceleration (the so-called Pierce system), and several other schemes are under consideration, and so far we can't tell which is best. An outstanding problem is how to manage the "fall" of the ions through a potential of several thousand volts without corona discharges, arcing, or excessive ion col-

FIGURE 1: Simplified schematic of an ion rocket using an acceleration-deceleration system. Such a system has been claimed to produce higher thrusts than can be achieved with ordinary parallel electrodes providing only acceleration. This claim has yet to be backed up by experimental data.

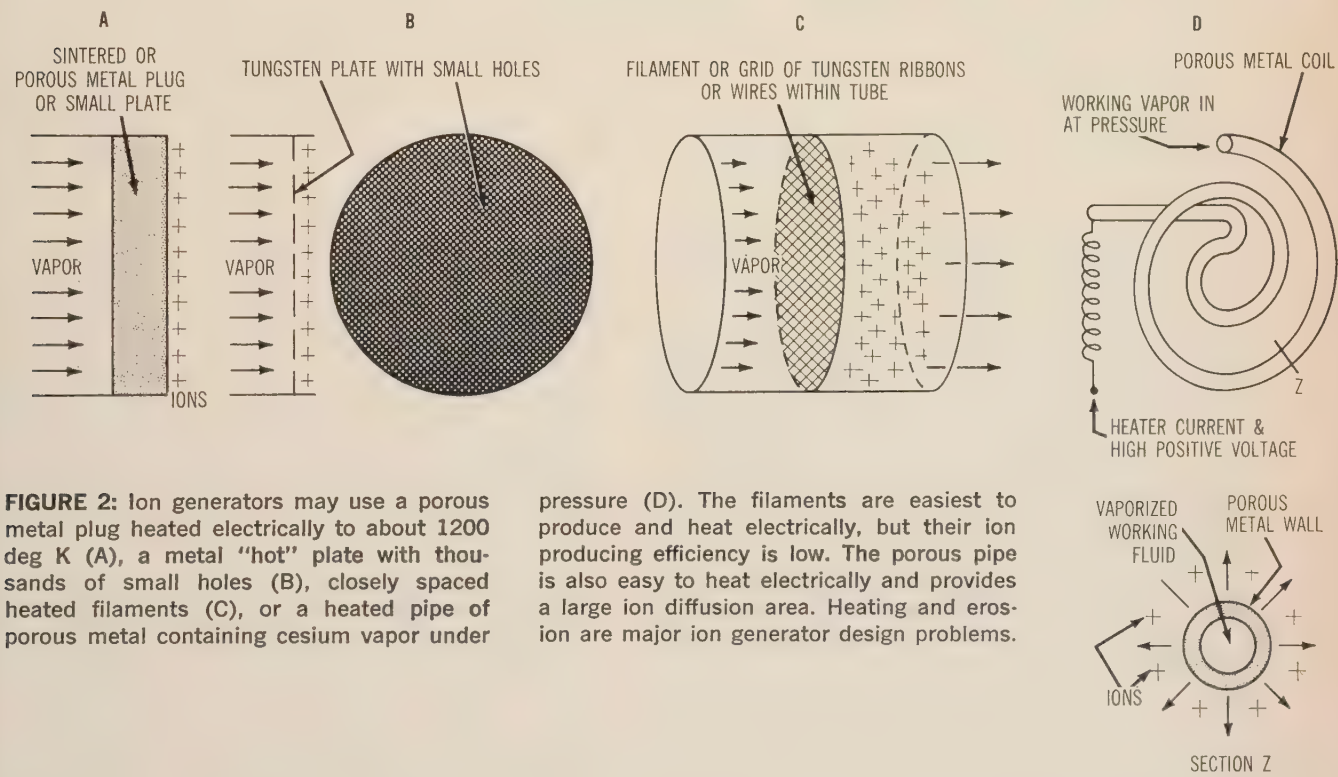
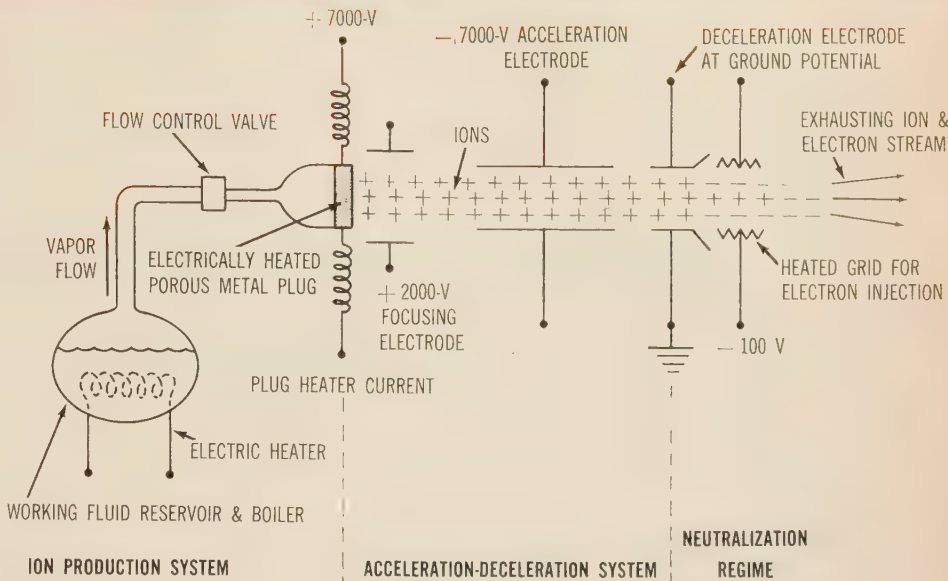


FIGURE 2: Ion generators may use a porous metal plug heated electrically to about 1200 deg K (A), a metal "hot" plate with thousands of small holes (B), closely spaced heated filaments (C), or a heated pipe of porous metal containing cesium vapor under

pressure (D). The filaments are easiest to produce and heat electrically, but their ion producing efficiency is low. The porous pipe is also easy to heat electrically and provides a large ion diffusion area. Heating and erosion are major ion generator design problems.

lision. The gun also must be designed so that it is compact, maintains the proper space charge and voltage distribution, and minimizes secondary emission. For its electrodes, heat transfer and sputtering pose problems.

The neutralization of the exhausting ion beam through the injection of electrons is a particularly tricky feature of the ion engine. The current approach is to place a heated-filament emitter that is at a few volts potential in or next to the ion stream. This emitter must be very carefully designed if it is to boil off a large cloud of electrons and yet cause no heat transfer

problems, prevent electron interaction with the ions in the final stages of acceleration, keep the electrons from drifting back to the ion emitter despite the attraction of a high positive voltage, and forestall a build-up of the space charge. (Because of the last consideration, the electrons are injected at low energies.)

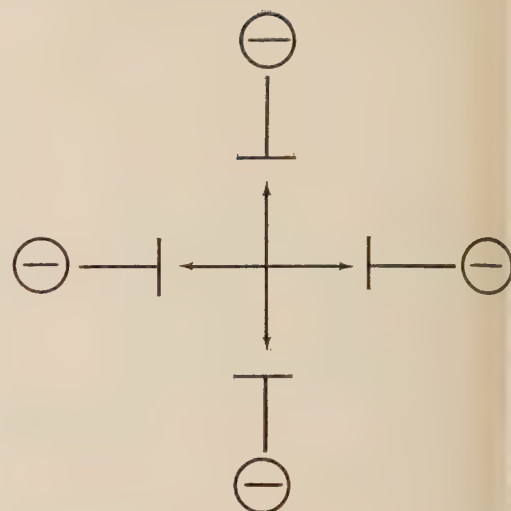
In the design of the overall engine, a very delicate balance must be maintained between ion generator characteristics, the mass of the working fluid, and the accelerator voltages even if only a low thrust level (of less than 1/2 lb) is required. Another overall prob-

more on next page

Comparison of Specific Impulses

Propulsion System	Propellant	Specific Impulse ¹ (sec)	Possible Space Flight Applications
Chemical	H ₂ & O ₂	430	upper stages of orbital vehicles & space probes
	best theoretical solid	290 ²	giant boosters, lunar re- torockets, small satellites
Nuclear	H ₂	700-1000	upper stages of orbital vehicles & space probes, heavy deep-space probes
Electric thermal arc	helium, N ₂	1200	orbit correction (?)
Plasma	lithium, N ₂ , air, etc.	1500-10,000	lunar-orbit vehicles, deep-space probes
Ion	cesium, rubidium, potassium, N ₂	10,-20,000	deep-space probes, plane- tary-orbit vehicles, con- tinuous acceleration, or- bit correction

(1) Values neglect the weights of tankage, propellant, and electric power source and are not necessarily optima. (2) At 500 psi and sea level.



IN THIS thrust-vectoring scheme, the four electrodes are at different voltages, so that an off-axis deflection of the ion beam results. This deflection in turn produces a small asymmetric thrust perturbation. It might be simpler, however, to provide for directional control by having a spacecraft carry several ion engines.

lem is that of thrust control, which can be done by varying the flow of the working fluid and/or the electric potential differences.

Thrust vector control could perhaps be achieved by applying voltage differentials in the accelerating region. Either segmented electrodes or additional vectoring electrodes in the ion stream would be needed for such a scheme. A problem would be posed by the effect of the voltage level changes on the thrust level.

Like all electric propulsion devices, the ion engine requires a power supply, which can be assumed to be a radioisotope or nuclear unit. As this power supply in a sense is equivalent to the propellant system of the chemical rocket, its weight is an essential factor.

Compared with the other electric propulsion systems, the ion engine has the advantages of a lower heat flux output and relatively simple operation (in certain applications). It has the lowest thrust, generally speaking, but probably also the highest specific impulse.

There is no doubt that, for deep-space missions for which midcourse corrections and slight velocity trimming are required, an ion engine is peerless—provided it is reasonably efficient, which depends largely on the availability of a light and simple power supply. For a spacecraft, such an engine could provide a continuous small acceleration (some fraction of one g) for years.

An idea of the hardware problems of ion propulsion is given by General Electric's design experience since late 1958, when the company began testing its first ion engine prototype. This XE-700-1 design used an indirectly heated screen-granule emitter made of tungsten and an acceleration-deceleration gun. As had been expected, the emitter heater proved inefficient. In tests with cesium as the working fluid, the engine ran at

six kilovolts at an acceleration-deceleration ratio of 6.

GE's next ion engine, the XE-700-2, had a directly heated wire-screen emitter of tantalum with an improved heater. In cesium tests at an acceleration-deceleration ratio of 5 and a measured interception (assuming no electrode currents) of 38 per cent, the measured efficiency was 14 per cent average and 19 per cent maximum for 1.45 kw input power at six kilovolts beam voltage. In controlled-beam operation, the electrode currents were as high as 75 ma. The estimated thrust was about 0.5 gm, and the specific impulse 9670 seconds.

With the XE-700-3, GE went to an electrically heated cesium vaporizer operating at high pressure and temperature. (In the earlier designs, the temperature of the cesium had been controlled by circulating warm oil.) Through improvements of the emitter's high-current contacts, the losses of heater power caused by contact resistance and inductive feed-through were cut from 44 to 20 per cent. This gain was balanced by an increase in the power required by the heater, which now had a larger area. In some tests of this engine, the interception was about 10 per cent.

GE's latest ion engine on which detailed design data are available, the XE-701-1, combines further emitter improvements with accurate Pierce acceleration geometry. The emitter is a hermetic tantalum structure rolled to a particular cesium conductance. A more compact vaporizer that needs less heat shielding is used. All electrodes are held exactly in position by self-aligning supports that apply tension to take up thermal expansion. The decelerator also functions as the neutralizer and is mounted directly in the ion beam. In the first tests of the XE-700-1, unusually large target currents were measured.—End

Gear drive reliability

starts with preliminary design

No matter how much design experience you have, by itself it won't prevent failures in your power transmission system. To be on the safe side, you should systematically rate each critical gear mesh in terms of operating speed, power dissipation, gear accuracy, finish, and backlash.

by **Nicholas S. Hodska,**

Design Engineer, Design Component Group,
Sikorsky Aircraft Corp.*

MECCHANICAL power transmission systems are basically reliable. But you can't get this reliability unless all the parts of the system have passed environmental tests even more stringent than those to which the complete assembly will be subjected. Merely specifying the environment to the gear supplier is not enough, nor can the designer be satisfied with nothing but mean-time-to-failure life test data on his components.

Three of the most common causes of gear tooth failures in transmissions are:

- underdesign or inadequate gear rating specs,
- inherent defects of the gear material,
- operational abuse.

The need for adequate gear specs and ratings is not appreciated by many design engineers. Often the so-called "safe" operating condition specified for the standard tooth form will subject the gear teeth to excessive stresses and lead to early failure. Very few specs or ratings for gear materials can be used directly in the design of a prototype or experimental design. Usually the designer must interpret his data in the light of his experience.

Mechanical and material defects in gear teeth may lead to unpredictable parameter changes, drifts, or instabilities in the transmission systems. Invariably, they limit service life and reliability.

Most gear manufacturers inspect every single gear they produce. By checking profile, spacing, eccentricity, and helix angle (all on automatically recording testers), they manage to catch almost all rejects. Still, most 100 per cent gear inspection procedures are really only 98-99 per cent effective. The design engineer therefore should set up his own inspection system for spotting the few defective gears that can be expected to show up in every shipment.

Reliability studies show that 50 per cent or more of all spur gear failures can be traced to misapplication of gears and improper specification of material. The situation may well be roughly the same for all transmission failures taken in their entirety.

The load-carrying capacities of gears vary according to the characteristics of the gear (such as the accuracy of its teeth), the design application and the nature of the loads to be driven, and the amount of vibration and noise (particularly at high speeds and low loads). Standards for rating the load-carrying capacities provide a universal method of comparison for normal operating conditions. However, these standard ratings are on the optimistic side. They are based on mechanical properties and surface durability and do not take into account thermal limitations. With caution, the R&D design engineer can use these ratings as specified (unless he is trying to exploit a single gear set to its fullest capabilities).

Full stress capability is used

Rating standards define gear limitations in terms of operating speed, power dissipation, accuracy, finish, and backlash. Maximum operating speed is usually defined first on the basis of allowable stresses in the gear materials and parameter stability. However, gear manufacturers are far from agreeing on this definition.

In most good designs, the allowable induced material stress equals the apparent induced stress at the root of the teeth, so that the full stress capability of the gear material is used. In hardened chrome-nickel steel, for instance, the allowable stress should be 75,000 psi if

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* Sikorsky Aircraft Corp., Stratford, Conn.

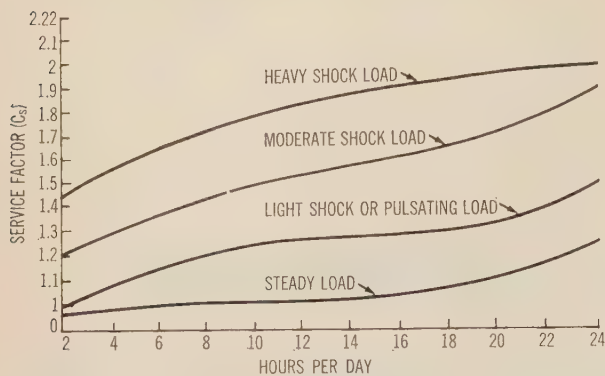


FIGURE 1: Typical service classification curves for accessory system gear drives.

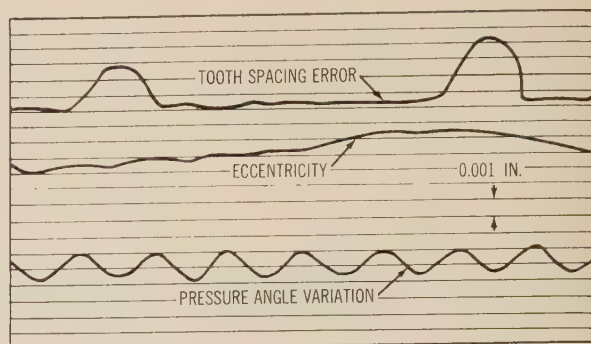


FIGURE 2: Recording of gear tooth spacing error, which may be limiting.

the inertia of the rotating mass or the amount of error in gear action is not a prime limitation.

The maximum material stress allowance should be based primarily on parameter stability. Unfortunately, in evaluating this relationship you can seldom pinpoint a specific stress above which the parameters are unstable and below which they are stable. Gear manufacturers therefore use varying interpretations of empirical stress velocity derating data (developed from gear tests) to account for varying characteristics of gear-tooth action.

Top allowable stress is needed

For forged steel of SAE-1030 quality, a 3500-fpm maximum velocity limit can be unsafe for a given type of drive, yet for another material this limit may be quite reasonable. What it all comes down to is that, to get precise data, the designer should find the gear failure rate with respect to rated maximum allowable stress.

Once you have a maximum operating allowable stress, you can base the power dissipation rating on the driving force transmitted from the driving pinion tooth to the driven gear tooth. The horsepower for which gears must be designed should include a service factor to account for power surges and shock factors.

The driving force (W) is found from:

$$W = 33,000HC_s/v \text{ lb},$$

where H is the transmitted horsepower; v , the speed of the gear at the pitch line (in fpm); and C_s , the service factor. If the turning moment on the gears is known:

$$W = 2Tp_d/n \text{ lb},$$

where T is the turning moment (in in.-lb); p_d , the diametral pitch (in inches); and n , the number of teeth in the gear.

If you calculated a service factor power rating for 24 hours a day, you would end up with a C_s of 1.25. But such power rating is quite unrealistic for gear systems designed to consume tremendous power for long periods. In gearing of this type—e.g., an accessory system for an airborne nuclear reactor—the maximum load and not the average load should be used in the service factor calculation.

In general, the C_s power rating of 1.25 is parametric and has little meaning as a realistic operating condition.

It takes infinite rigidity (not too practical for most transmission systems) or extreme gear accuracy to hold this value.

Designers often overlook the significance of a rise in bearing temperature beyond the case temperature at the full power rating. A gear drive with a heavy shock load might be quite satisfactory with a C_s of 2 when the gear differential is small. On the other hand, with a large gear differential, however, strains may occur even at lower loads and temperatures and in the end lead to fatigue due to recurrent temperature cycling whenever power is applied and removed.

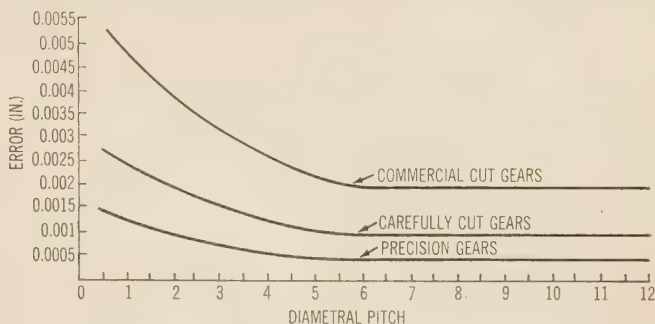
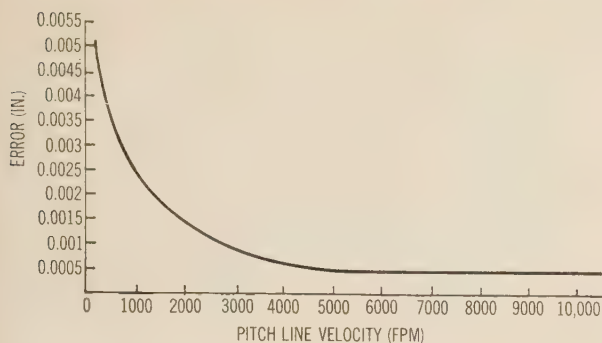
The thermal time constant of most gear systems is short enough for the bearings to heat up and cool during the average working cycle. Two temperatures therefore should be defined before a power rating is set up: a maximum bearing temperature based on parameter stability and a maximum temperature differential between gears. Often this temperature differential will be the limiting reliability factor.

Nevertheless, you seldom find a temperature differential specified in conventional power ratings, nor does it always show up in the gear temperature tests normally run to find the allowable maximum mating teeth operating temperature (based on continuously applied power). The only way to be safe is to run intermittent gear temperature tests designed to produce maximum temperature differentials.

Line slope shows C_s resistance

Figure 1 shows a typical rating curve as suggested by most gear manufacturers. Loads are given as steady, light, moderate, or heavy, depending on the system. C_s is usually rated at about 1 for an 8-hour working period. The line slope shows the service factor resistance.

Gear accuracy ratings are usually related to specified gear loads and speeds or to the specific teeth errors (whichever is limiting). It makes little difference whether you take involute-profile error or tooth-thickness error. Many engineers use the latter, claiming it is the more precise guide. They believe that the accuracy of the pitch diameter affects the backlash and in the end causes interference trouble similar to that produced by



PERMISSIBLE (left) and probable (right) gear tooth error. Together with spacing, eccentricity, and helix-angle

errors, this error belongs among the most dangerous types of gear tooth deviations.

gear eccentricity. The margin between rated and acceptable accuracy—the point at which the least accurate gear units will break down—is found from classification testing data (Fig. 2).

When you consider all errors in combination, you are following an approach that is realistic in view of the actual operating conditions. From the test charts you can determine the magnitude and location of various inaccuracies and then the primary classification parameters.

It is usually dangerous to operate gears at or near their rated loads. Transients or other variation can easily cause failure. For example, if a precision gear rated at 0.0003 in. tooth-to-tooth spacing error is to operate at low temperatures, a minimum extra safety factor of 10 per cent should be added to any safety factor you might normally apply to allow for transients and other system variation.

A safety margin must be added

It cannot be overemphasized that profile, spacing, eccentricity, and helix-angle errors are the most dangerous types of gear teeth deviations. A substantial safety margin should therefore be added to all calculations of these errors.

The backlash ratings of most gear units are generally quite arbitrary. The allowable backlash is the amount by which a gear tooth space can exceed the thickness of an engaging tooth (with reference to the effect of variations in gear-shaft-center distance) within the accuracy rating. In gear systems in which peak backlash values are many times higher than the average, backlash ratings can cause you trouble—particularly if there is an overrunning load or if the drive reverses often.

The maximum peak allowable backlash, which can be an important design factor, is usually given on the spec drawings. In any gear application involving peak backlash values, the designer should verify that the specified value falls within the tolerance established by the American Standards Association (see Table).

The industry's standards for rating the load-carrying capacities of gears normally are conservative. Failure rates for gearing that is pushed to its maximum operating ratings can range from a few per cent

Typical Backlash Specifications*

Spur, Helical & Bevel Gears	
Diametral Pitch	Backlash (in.)
1	0.025–0.040
2	0.014–0.020
4	0.007–0.011
8	0.004–0.006
16	0.002–0.004
32	0.002–0.004
Worm Gears	
Circular Pitch	Backlash (in.)
1/8	0.002–0.004
1/4	0.003–0.005
1/2	0.005–0.007
1	0.009–0.014
2	0.017–0.025
4	0.032–0.050

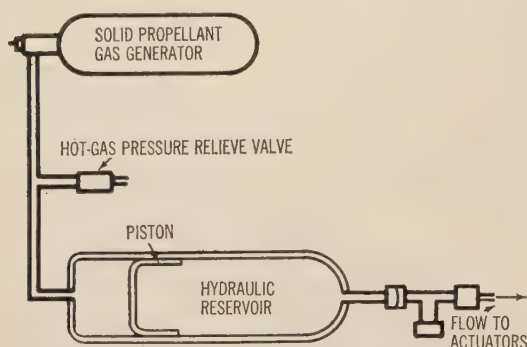
* Minimums were measured at the pitch circle, or the tightest point of the gear.

to over 10 per cent per 500 hours (in extreme cases).

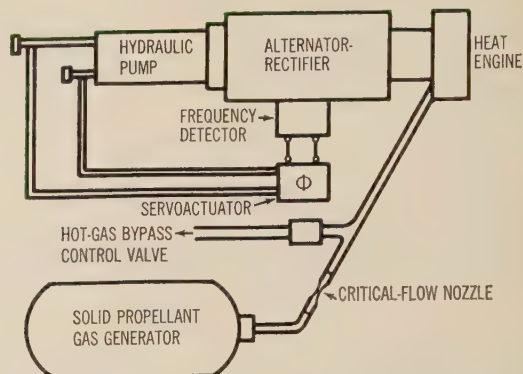
Fortunately, high failure rates drop off very quickly under derating conditions. Many transmission installations have shown failure rates of 0.01 per cent or less per 1000 hours when the gears are operated very conservatively.

One of the major problems facing design engineers today is that they have no accurate method of correlation ratings to failure rates. In most cases, they must rely on their practical experience in deciding the amount of derating in a given transmission application.—End

Accessory Systems



CURRENT SOLID-FUELED non-propulsive power systems use high pressure hot gas to drive either a piston deliver-



ing hydraulic fluid (left) or a heat engine (right). They are best suited for short missions.

Non-propulsive power for advanced vehicles—II

This is the second in a series of articles on non-propulsive power. A review of the more conventional systems under consideration, it follows last month's discussion of basic mission requirements. Next month's article will take up the "exotic" systems—fuel cells and solar and nuclear types.

by **Robert Curran**, Senior Group Engineer,
Physics Staff, Aero-Space Div., Boeing Airplane Co.

VEHICLE DESIGNERS are continuously on the lookout for the lightest power system they can get that will be available in time for installation in the vehicle—all at minimum cost to the overall space system. When no single power system fills the bill—the usual case—they must choose the system that shows up best

* Aerospace Div., Boeing Airplane Co., P.O. Box 3707, Seattle 24, Wash. This series is a condensation of a paper, "The Applicability of Non propulsive Power to Space Vehicles," given at the Vickers Aircraft Hydraulic Conference in Detroit, Mich., last November.

in a comparison of strong and weak points.

Why non-propulsive power is needed, in what quantities it will be required, and what performance factors must be considered are all critical questions that influence the selection of a particular design. But more important is the question, Just what is available in the way of a production or lab prototype, and what can it do?

One of the most widely accepted non-propulsive power systems is based on the use of a storage battery as the energy source. Although little research money has been spent on battery systems in the past few years, they still have a number of strong features that make them competitive with the newer and more exotic system.

Battery-powered accessory power units (APUs) have been the commonest form of non-propulsive power in more space vehicles and missiles. As a result, we have lots of service experience with them. Their storage life is excellent, and so is their reliability, especially when static inverters can be used to meet the ac power requirements. Another point in favor of battery units is that you can put together a system of practically any

size you might need from off-the-shelf or readily developed parts.

But battery systems have their shortcomings, too. As power needs and operating time increases, the weight of the battery APU soon exceeds that of competitive equipment. And since the battery has a dc output, any requirement for ac or hydraulic energy means a conversion and power waste due to conversion inefficiencies.

Continued charge-discharge cycling is also a problem. As the percentage of available energy per discharge increases, the cycle life of the battery decreases. For long-life applications, the system designer may find himself limited to using as little as five per cent of the total battery energy per discharge, so that he again must increase the battery weight for a given amount of usable power.

Another drawback is that a battery provides no heat-sink capacity. Therefore, a separate equipment cooling system must be carried. Finally, in continuous operation in space, batteries may suffer from zero-gravity effects.

In view of all these points, the applications for which the battery power system looks promising are:

- **Medium Power and Short Time**—Battery systems have been and will continue to be used for power levels up to about two kilowatts when the operating time ranges from five to 30 minutes, as in emergency escape capsules and ICBMs.

- **Low Power and Medium Time**—Battery systems will be used for power levels up to about 500 W. When the operating time is on the order of 1-5 hours, as in non-orbiting space probes.

Experience shows that three APU types, if available in the required size, may be more attractive than the battery: solid- and liquid-fueled mechanical heat engines and the flywheel storage system. Each type has an advantage over the battery when a variety of electric voltages and frequencies is needed as well as hydraulic energy. However, these advantages are often outweighed by problems of initial costs and lack of operating experience.

None of these systems is competitive with the battery in storing and then supplying auxiliary energy to a solar power system while the vehicle is in the earth's shadow. The fuel cell may offer competition in this area.

Continued battery work is needed

Since the battery will continue to have a place in the line-up of space flight equipment, two major areas of battery development need continued attention aside from further efforts at weight reduction:

- Batteries must be developed that are not adversely affected by continuous operation in the absence of gravity.

- For use as storage devices in solar-power systems, we need batteries that can take continuous charge-discharge cycles without servicing.

Two basic types of solid-fueled non-propulsive power systems are in use:

- systems using hot high pressure gases (from the combustion of a solid fuel) to drive a piston delivering fluid to the vehicle hydraulic system;

- more commonly, systems using the hot gas to run reciprocating or turbine heat engines.

A big advantage of the solid-fueled APU is that it can provide power in a variety of forms (ac, dc and hydraulic) at less weight than can battery systems. Solid fuels also are easily stored and handled. In addition, the solid-fueled APU can be re-used, so that it's easy to run a ground check of the entire power systems—something that's not true for some battery systems.

Because solid propellants do not have to be pumped or expelled from a container, the solid-fueled system is less complicated than its liquid counterpart. Another advantage of solid over liquid fuels is that they do not lead to problems under zero-gravity conditions.

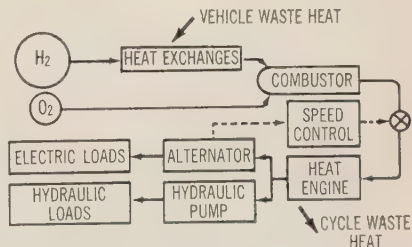
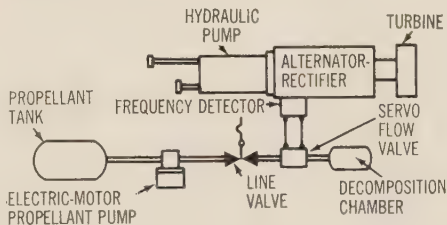
But solid-fueled equipment also has its limitations. The available solid propellants burn at a relatively fixed rate. Therefore, you must size the fuel grain for the expected peak power and eliminate the excess gas during periods of low demand. As a result, specific fuel consumption is high, and unexpected load peaks cannot be accepted.

Installation problems may crop up

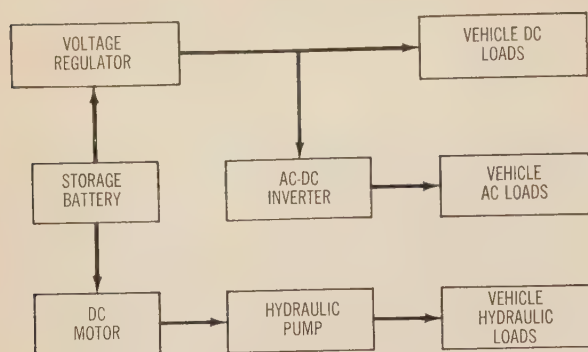
The installation of a solid-fueled system may be more difficult than that of a liquid type because grain dimensions are fixed by power level and operating time. (Fluid tanks can be made in almost any shape.) Furthermore, solid-fuel burning rates change with grain temperature, so that the gain weight must be increased to take care of low temperature storage conditions.

Right now, lead time and development costs for a given solid-fueled system may be higher than those chargeable to an equivalent battery system. But these factors will become less significant as more work is

more on next page



LIQUID-FUELED, open-cycle, expansion-engine power systems may use either a monopropellant (top) or a bipropellant combination (bottom).



BATTERY power systems, backed by lots of operating experience, still rank high in the designer's estimate.

done on solid fuels. On the score of reliability, high speed rotating parts may put the solid-fueled systems at a disadvantage in comparison with an all-static battery system.

Experience shows that most of these shortcomings don't matter for short missions, especially when the power requirements are below 10 kw and the duty-cycle is less than 15 minutes. As power and time are increased, the inherently poor specific propellant consumption leads to an excessive weight penalty. The larger fuel grains required at high power become difficult to install and costly to develop.

Various ground-to-air, air-to-air, and intercontinental missiles are ripe for solid-fueled power equipment. However, before choosing this type of power unit, the vehicle designer must study its liquid-fueled counterpart and the battery-powered APU. Both systems will be closely competitive with the solid propellant unit—in some cases, they will be clearly superior.

To extend the application of solid-fueled power equipment, we must formulate fuels whose combustion rate can be controlled. In this way, we will be able to lower fuel consumption and so system weights. The development of jelled fuels is a step in this direction. In addition, we need rotating equipment of proven reliability.

Liquid-fueled, open-cycle expansion engine power systems are also being considered. The first and most highly developed of these systems uses the hot decomposition gas of a monopropellant to drive an expansion engine. The second, something of a newcomer still, uses a bipropellant combination of cryogenic fluids (hydrogen and oxygen) to drive the expansion engine.

Heat sink soaks up full load

Bipropellant hydrogen-oxygen systems offer a propellant heat sink that can soak up the full vehicle equipment load. Hydrazine, the best of the available monopropellants, also provides a heat sink, but it is limited to about 25 per cent of the total equipment cooling load.

Liquid-fueled power systems have a number of decisive advantages. Most important is that their power output can be closely controlled without wasting propellant. They can also accept high peak power demands with little or no "extra weight" penalty.

In contrast to solid-fueled designs, liquid-fueled systems are fairly easy to stop and then restart. A liquid system therefore can be used to supply intermittent loads in a space vehicle that normally depends on solar power. Because propellant is consumed in flight, the liquid-fueled system contributes much less to re-entry weight than does an equivalent fixed-weight solar or nuclear power system.

The fuel tanks of a liquid system are easier to install in a vehicle than solid propellant grains with their fixed dimensions. Ground checkout is also easier. Like the solid systems, the liquid ones can deliver power in different forms without any conversion.

Hydrazine, an excellent propellant, is storable and has a high density of some 62.5 lb/cu ft. As used in present turbine equipment, it is consumed at 4.8 lb/hp-hr. We have a fair amount of experience with hydrazine as a fuel, since it has been used successfully on an intercontinental cruise missile.

Hydrogen-oxygen-fueled systems offer a considerably lower propellant consumption—1.5 lb/hp-hr.

Before deciding that liquid-fueled systems are the answer to all big problems, the designer must consider some disadvantages he would have to accept:

- All liquid-fueled systems suffer from zero-gravity problems. A positive means of delivering the fuel from the tanks to the combustion or decomposition chamber is needed.
- Controls are more complicated than with a solid-fueled system (the bipropellant design being more complex than the monopropellant type).
- Hydrazine's high freezing point (around 32 deg F) can become a problem. Hydrogen also is at a disadvantage when it comes to storage, handling, and operating experience.
- Hydrogen's low specific propellant consumption of 1.5 lb/hp-hr is offset to some extent by high tankage volumes, which in turn may affect the vehicle design. (Hydrogen is only one-sixteenth as dense as hydrazine.)

Hydrazine has good storability

The two liquid-fueled power systems that we have discussed are competitive with each other for the shorter missions. For long duration, the hydrogen-oxygen system has a clear edge, provided the vehicle designer can accept a volume penalty as the price of a saving in weight.

Hydrazine-fueled equipment will be used for missions lasting up to about 2-3 hours, at expected average power demands of as much as 50 kw. For shorter periods, the power demand may safely run into hundreds of kilowatts.

Because of its excellent storage characteristics, hydrazine-fueled equipment can be used in many strategic missile applications. It can also be used to provide re-entry power for long-duration space vehicles that depend on solar or nuclear power for most of their flight.

Hydrogen-oxygen-fueled system will be needed on manned space flights when mission times begin to exceed 2-3 hours. Studies show that, from three hours to three days, the hydrogen-oxygen system is the most practical available power system. Although its volume is large, the weight advantage makes the volume penalty acceptable.

Liquid-fueled systems do not face too much competition from solar and nuclear designs. These types are almost as heavy as or heavier than the hydrogen-oxygen

system for many missions, and of course they have their own peculiar problems. Fuel cells are another matter. Some engineers claim fuel cells are as good as, if not better than, the hydrogen-oxygen heat engine system. The trouble is that not enough data are available to define the capabilities of fuel cells. Probably, when the fuel cell does become competitive, it will be for long missions (more than three days).

What will curtail the use of liquid-fueled heat engines more than anything else is a general lack of confidence in the reliability of these units. This shouldn't come as a surprise—obviously a mechanical system on which the life of a crew may depend and that may have to run in a space environment for 10 days or more without failure must have proved its endurance before a designer can bring himself to accept it. Immediate steps must be taken to build endurance and reliability into liquid-fueled equipment.

Better hydrogen tanks needed

Another problem is that hydrogen systems are limited in endurance to the storage period of liquid hydrogen. Better tank design therefore is a must.

Interest in closed-thermodynamic-cycle APUs has been limited so far. In these systems, the combustion heat from chemical fuels is converted to useful power. The mechanical equipment is the same as that used with nuclear reactor systems; the heat source is similar to that used in chemically fueled open-cycle systems.

Proponents of the chemically fueled closed-cycle thermomechanical power system point out that this design can burn many bipropellant combinations at stoichiometric temperatures without subjecting the mechanical heat engine to high thermal stresses. With oxygen and hydrogen used at the 8:1 ratio characteristic of stoichiometric conditions, the fuel volume is lower than that needed for an open-cycle system—you have to have three pounds of hydrogen for each pound of oxygen in an open-cycle system. In another respect, however, the small quantity of hydrogen used by the closed-cycle system poses a problem—it limits the heat sink capacity.

About the same fuel consumption is predicted for closed- and open-cycle design. However, the waste energy of the closed-cycle heat engine must be eliminated through a radiator. (Open-cycle systems remove heat in the exhaust gas.)

Many of the shortcomings of the nuclear reactor system also apply to closed-cycle systems, since both systems use a thermomechanical heat engine. For example, the radiator can be damaged by meteorites. Boiling and condensation of liquids at zero gravity also present problems.

All in all, the closed-cycle system fails to offer any significant advantage over competing designs. It actually has so many limitations that it "is hard to foresee much of a future for it."

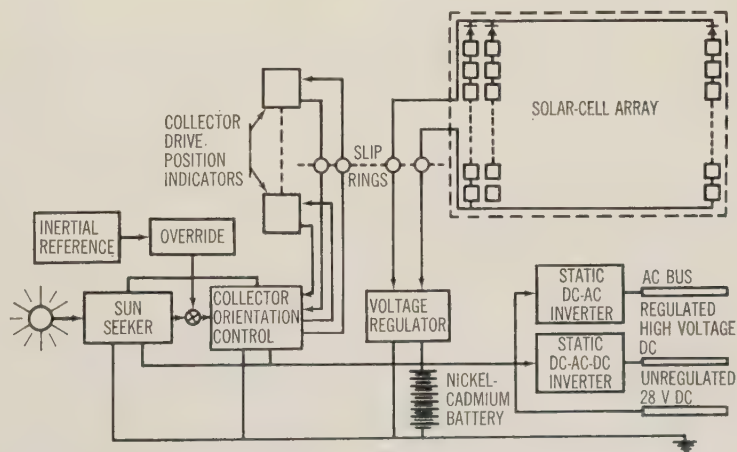
What with the many advantages and disadvantages of the systems we have described it's obvious that the designer faces quite a problem when he must pick a non-propulsive power system for a given vehicle. Engineers in companies like Boeing would like to have a list showing the specific non-propulsive power equipment considered best for future vehicles on the basis of factors like power needs and mission length. But they know they can't have it.

Selection criteria are complex

The relationships between the vehicle characteristics and mission requirements on the one hand and the non-propulsive power system on the other are so complex and affected by so many variables that it is impossible to pick a power system without exhaustive analysis of the problem. There is only one exception to this rule: For the vehicle that needs large amounts of power for long periods, a nuclear system is the obvious answer. Otherwise, all that the designer can be sure of today is:

- Battery, chemically fueled open-cycle, solar-photovoltaic and nuclear systems will be used over the next few years.
- Fuel cells and solar-thermionic, solar-thermoelectric, and solar-dynamic conversion systems show promise but are not yet competitive.—End

SOLAR-PHOTOVOLTAIC power system is one of the newer designs that show promise but are not yet competitive.





FORD VIBRATION INSTRUMENTATION: The Ford Motor Company entered the experimental gas turbine engine field in 1952. The Ford Turbo Machines Department is now engaged in research and development of a turbine engine and a working model has been tested in a tilt-cab truck. An obsolete engine, the Ford 702, has developed 160 horsepower at shaft speeds up to 36,000 rpm. ■ A new supercharged 300 horsepower turbine engine was recently announced by Ford Engineers. Known as the "704," the engine weighs 650 pounds installed, compared to 2,700 pounds for a truck diesel engine of comparable horse-

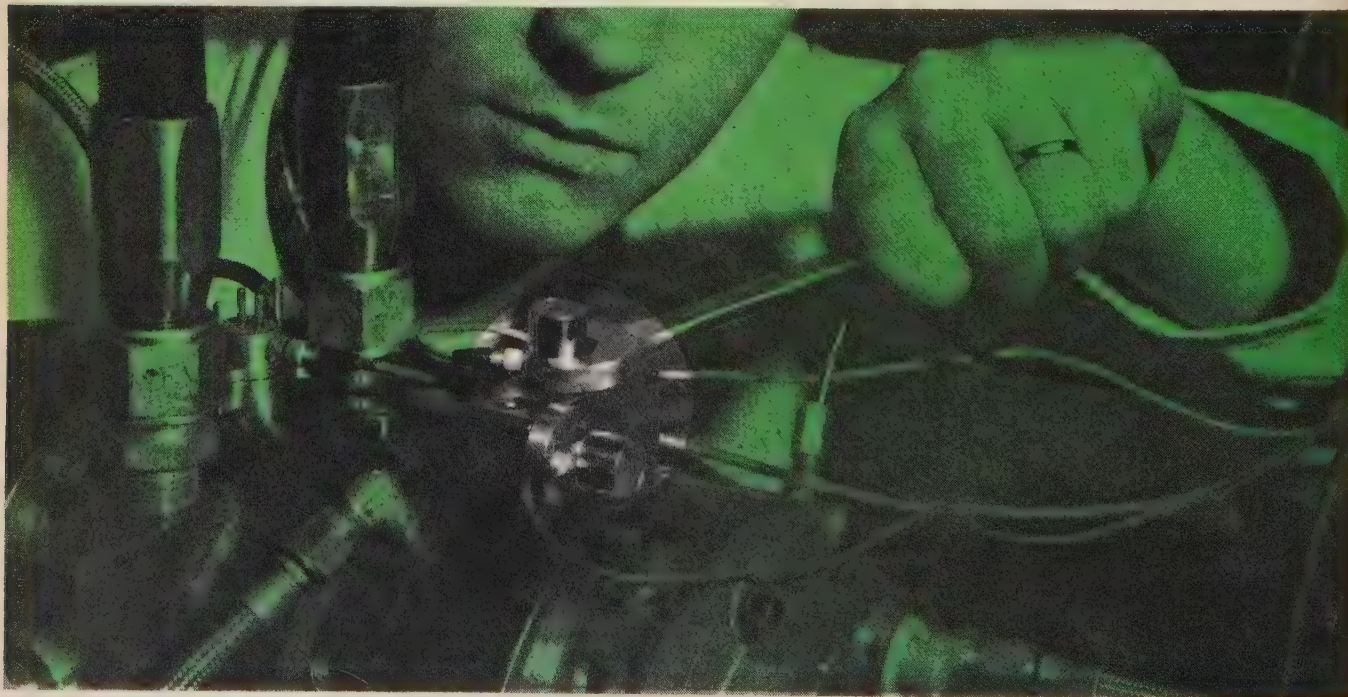
ENDEVCO TRANSDUCERS SOLVE VIBRATION ANALYSIS PROBLEM

power. The engine has two stages of compression, each operating at a 4:1 pressure ratio. Two burners are used for driving the dual compressors, the low speed wheel turning at 46,500 rpm and the high speed wheel at 91,500 rpm.

THE PROBLEM: The Ford Test program requires a wide variety of instruments to measure, control and record performance data of component parts. Measurement of vibration, for example, is a critical factor in this program. Vibrations that may cause metal fatigue, oil film breakdown, overheating, etc., are discovered during tests on individual engine "stands."

THE SOLUTION: Ford engineers use a total of six Endevco Series 2200 Accelerometers providing frequency responses up to 6,500 cycles per second. The accelerometers are connected to bearing test rigs, for example (see photo). The accelerometers relay measurements of acceleration movements in turbine shafts from three coordinates (radial vertical, radial horizontal and axial). Temperatures of the metal housings to which the standard Endevco transducers are attached average up to +150°F. Temperatures at which the water-cooled, heat-resistant models are used range up to +1000°F or more. The large self-generated output of the Endevco accelerometers eliminates the need for additional stabilization of a power supply.

THE RESULTS: The Endevco transducers are attached with a single-pole threaded bolt. The signal is fed through an Endevco amplifier to an oscilloscope or panoramic analyzer. The analyzer concentrates on a small section of the total signal and may present from 4 to 10 harmonic vibrations of different frequencies being fed from the unit at one time. This analyzer separates the frequency bands into individual bands, which it then sweeps from 20 to 40,000 cycles every second, measuring the frequency and amplitude in millivolts. ■ Ford Technicians convert these vibration records by mathematically integrating acceleration with respect to time to obtain the displacement or housing vibration. Thus, they locate the sources of objectionable resonance and take steps to eliminate or reduce vibration in the overall design. ■ Endevco accelerometers have also served as pickups for determining spring rate and damping characteristics of rubber bonded bearings. • **ENDEVCO CORPORATION** • 161 EAST CALIFORNIA BOULEVARD PASADENA, CALIFORNIA • PHONE SYCAMORE 5-0271



Close-up shows two Endevco Accelerometers on bearing test rig in Ford Instrumentation Section, Dearborn, Michigan. Cable passes to Endevco Amplifier (not shown on right).

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Grumman Gulfstream

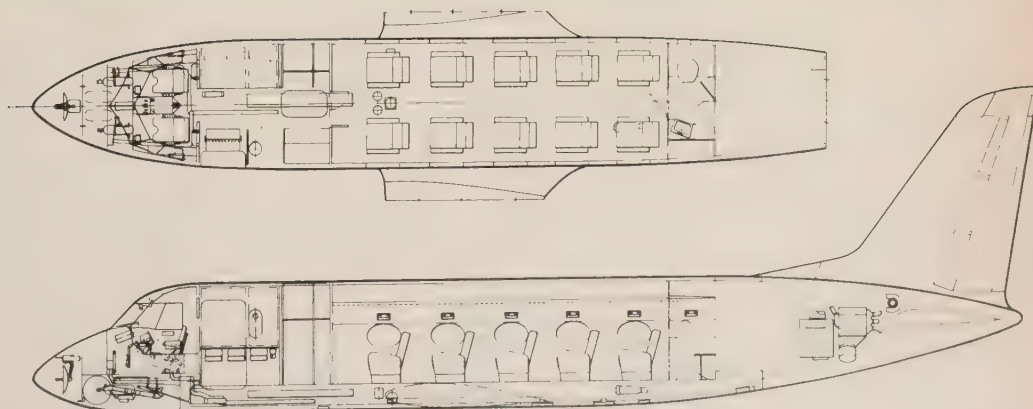
features low power loading

LOW POWER LOADING is a prime feature of the trim Gulfstream executive aircraft developed by Grumman Aircraft Engineering Corp., Bethpage, N. Y. Powered by two Rolls-Royce RDa-7/2 turboprop engines, each rated at 2105 eshp for takeoff, the plane has excellent single-engine performance. Single-engine service ceiling at 32,500 lb takeoff weight is 17,000 ft; two-engine ceiling is 36,000 ft. Maximum range is 220 miles plus a reserve of 200 miles and 45 minutes' fuel. Cruise speed is 370 mph at 25,000 ft altitude (pressurized) and 32,500 lb takeoff weight. The plane is designed for a maximum (licensed) takeoff weight of 33,600 lb and a landing weight of 32,000 lb. Takeoff ground roll on a hot day (113 deg F) is 2390 ft at 31,000 lb gross weight. On a hot day and with one engine out, the field length needed to clear a 35-ft obstacle is only a little over 4000 ft at 32,500 lb gross weight. The plane is 64 ft long, 22 ft, 9 in high, and has a wing span of 78 ft, 6 in. Write in No. 71 on Reader Service Card for more information.

by Irwin Stambler, Associate Editor



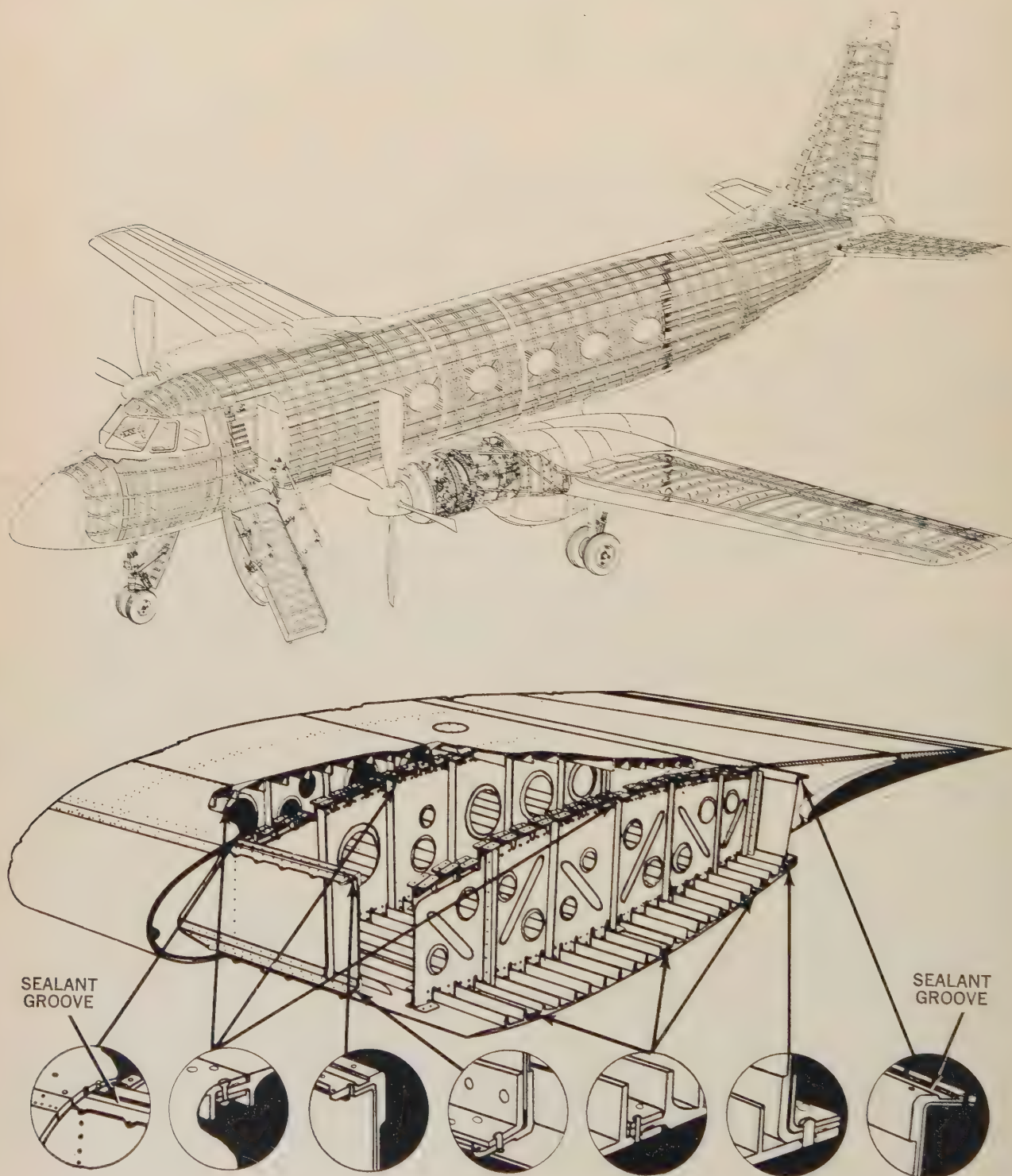
SEATING ARRANGEMENT
of Gulfstream for 10 passengers can be modified for either 12 or 19 passengers.

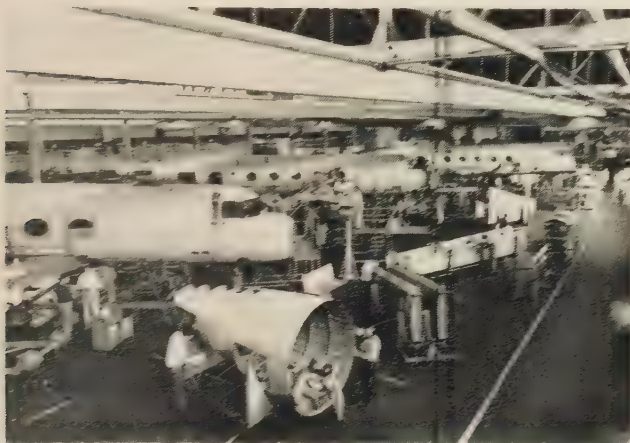
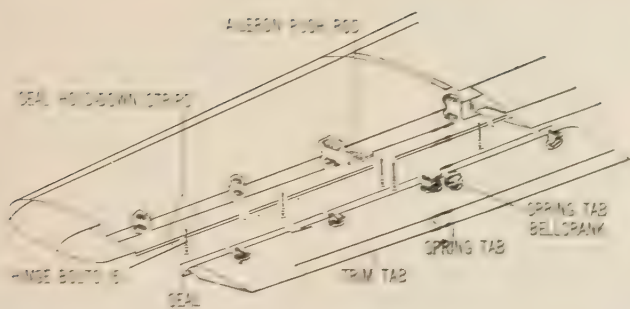


DESIGN PROGRESS continued

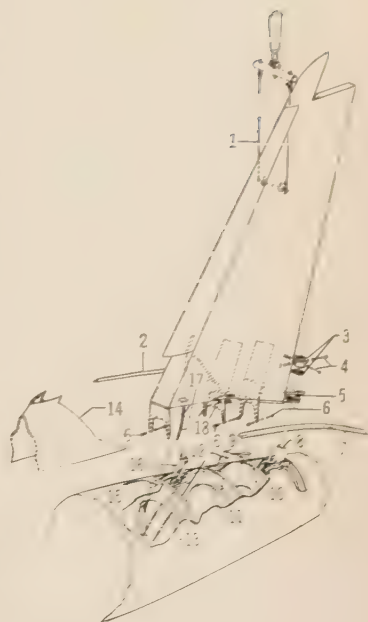
FRAMES AND STRINGERS in fuselage (top) are mainly of 2014 clad aluminum. All skins are 2024 ST. A minimum skin gage of 0.04 in. is used to permit countersinking of Martin-type rivets. No dimpling or spot-welding is used in the pressure cabin area. The 0.04-in. minimum gage provides a gross hoop tensile of 8450 psi at 6.55 normal cabin pressure. Two-inch-wide 0.032-

in. 7075 ST crack stoppers are riveted to the skin at each floating frame location. Bottom: Wing is a two-spar box beam that is continuous across the plane's centerline. Upper and lower covers are machined from 7075 stretched plate stock and integrally stiffened. Channel groove tank sealing is used, with non-curing Thiokol rubber injected under pressure.

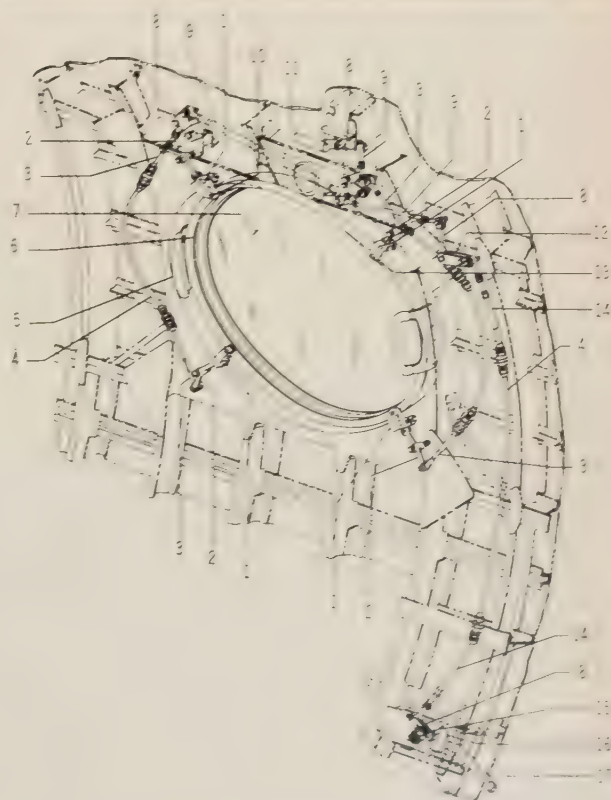
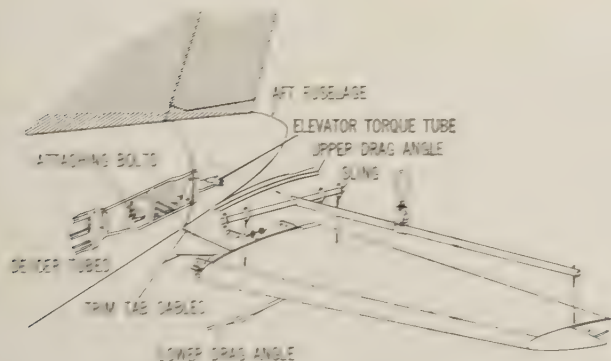




AILERON installation (left) and fin installation parts (right): (1) sling, (2) right drag angle, (3) torque tube collar and retaining ring, (4) collar attach bolts, (5) lower rudder hinge fitting, (6) fin attach bolts, (7) left drag angle, (8) torque tube, (9) gust lock push rod attach bolts, (10) gust lock push rod, (11) rudder control push rod, (12) rudder control push rod attach bolts, (13) trim tab cables, (14) fin fairing, (15) terminal strip, (16) de-icer tubes, (17) top anti-collision light wiring, (18) rudder control bellcrank. Left: Gulfstream production line.



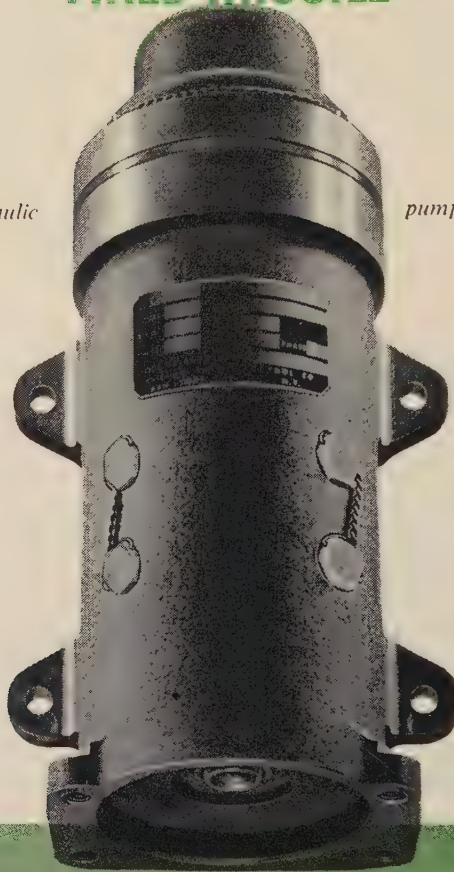
CABIN WINDOW assembly and installation-release mechanism (right). Window retainers are 2014 ST forged rings with T-shape cross-section. The window consists of two pieces of 0.35-in. stretched Plexiglas 55. Mechanism parts are: (1) cam assembly, (2) lever assembly, (3) terminal, (4) Teleflex cable, (5) handle assy., (6) seal, (7) glass assy., (8) bellcrank, (9) push rod, (10) camset screw, (11) handle, (12) link assy., (13) pad, (14) Teleflex rod, (15) spring, (16) seal plate, (17) handle. Below: Stabilizer and fin are conventional three-cell, three-spar box beam sheet stringer designs.



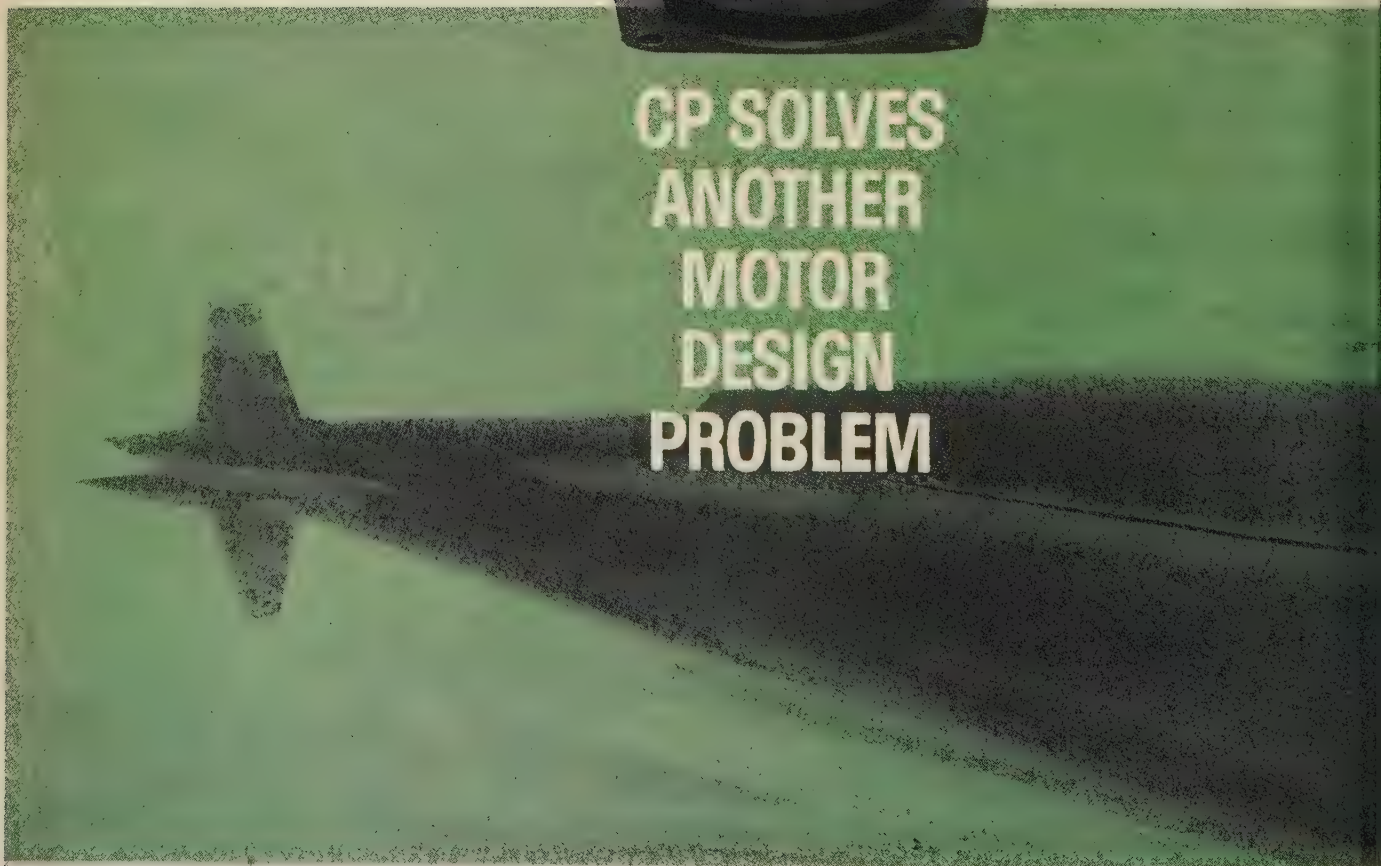
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DC-86 Motor drives a hydraulic

pump on the Polaris Missile.



CP SOLVES ANOTHER MOTOR DESIGN PROBLEM



PROBLEM

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5. Have extremely light weight.

SOLUTION

by Chicago Pneumatic

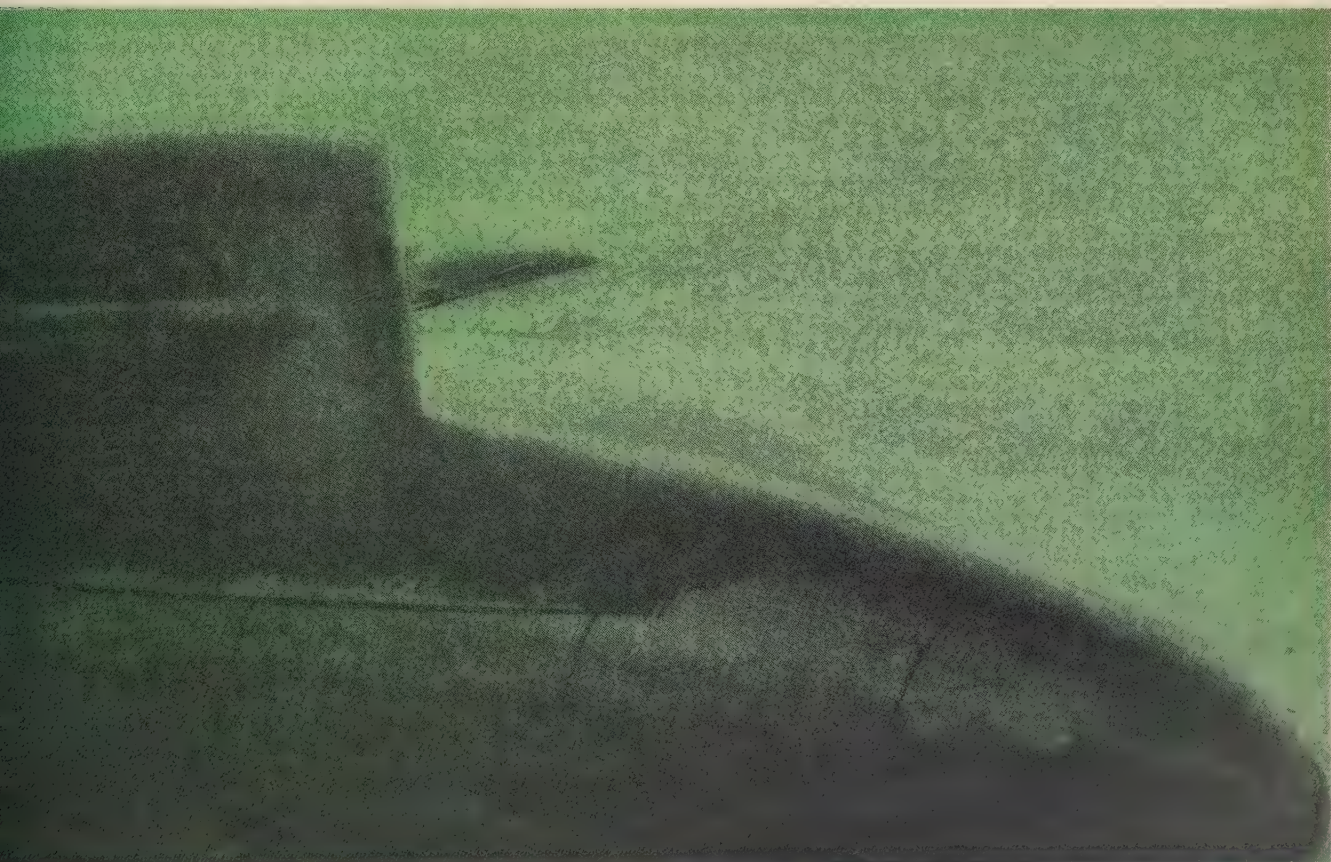
CP design engineers, drawing on wide experience in developing special function motors, came up with the DC-86. This motor weighed only 6 pounds — approximately 1.5 pounds lighter than other motors considered.

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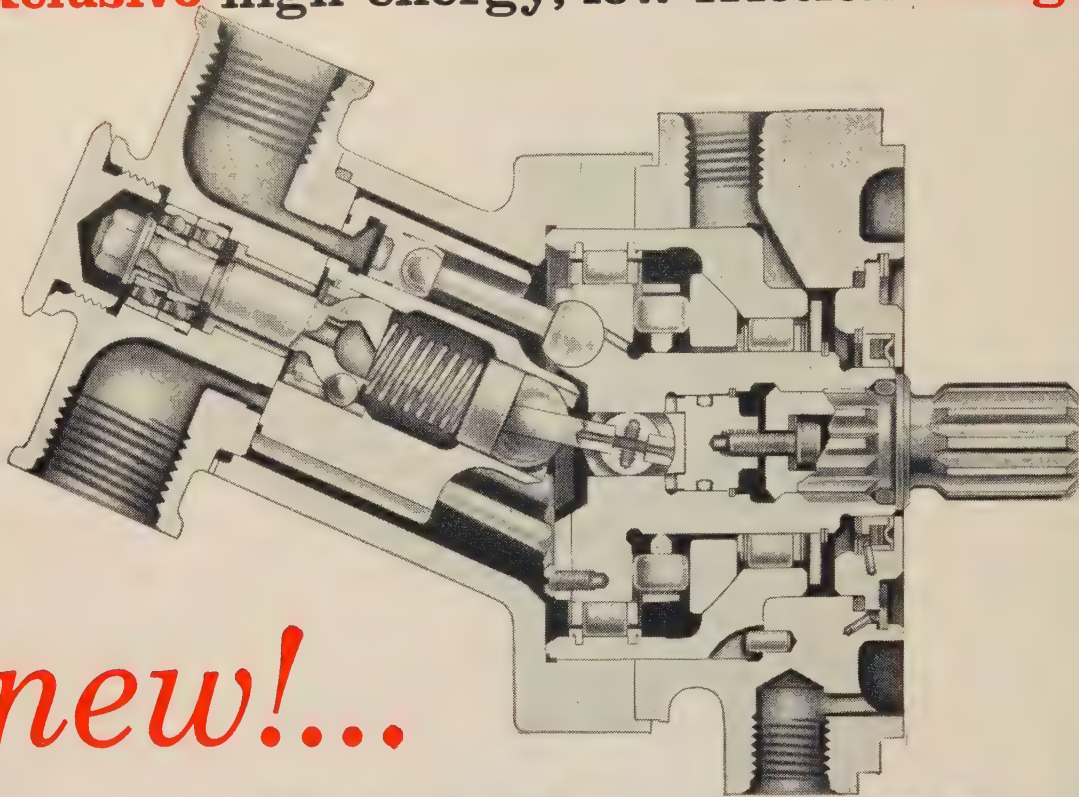
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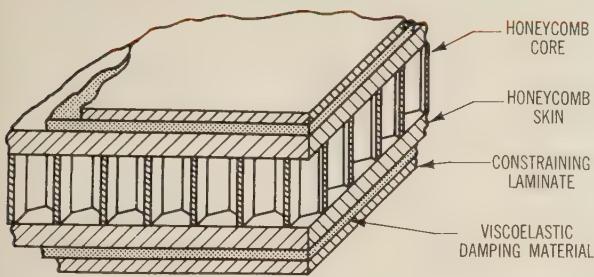
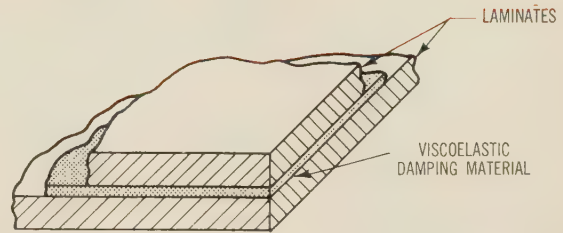


FIGURE 1: Laminated and honeycomb damped structural sheet. The laminates carry the load. Under flexural vibra-



tion, the viscoelastic damping layer is subjected to cyclic shear strain, which dissipates energy.

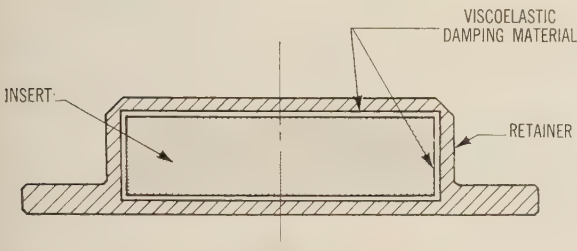
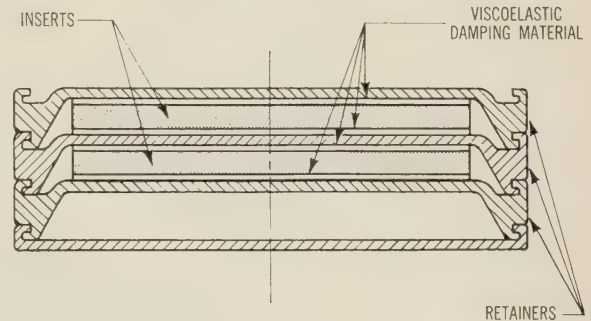


FIGURE 2: Cross-sections of two strip damper designs.



Built-in damping: new answer to structural vibration

Resonant-vibration control is becoming increasingly important in view of the high vibration and noise levels of new high energy power sources. Such solutions as rigidization, decoupling, and detuning tend to add too much weight. A more profitable approach appears to be built-in damping.

by **Jerome E. Ruzicka**,
Staff Engineer, Barry Controls, Inc.*

IN MANY new design regimes, a structure must withstand not only static load but also the destructive effects of high-peaked dynamic loadings and of fatigue from transient shock or sustained vibration. Such immunity can be achieved if enough damping is included in fabrication to limit the amplification of vibration at structural resonance. In designing for modern dynamic environments, the stiffness, weight, space, and damping properties of a structure must be considered as a combined design criterion.

A structural design that is highly damped usually weighs more than a conventional design on the basis of equal static stiffness. However, resonant vibration

* Barry Controls, Inc., Watertown, Mass.

more on page 63

PREDICTION..



JACK & HEINTZ, Inc.

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DESIGN REPORT AVAILABLE: An engineering folder, outlining design elements and tabulating characteristics of 16 SECSYN machines, is available on request to: Jack & Heintz, Inc., 17600 Broadway, Cleveland 1, Ohio.

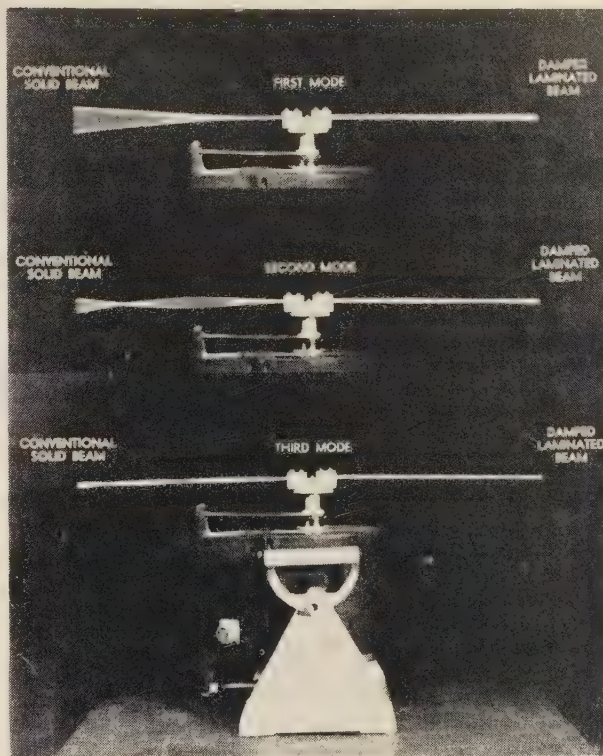


FIGURE 3: Vibration amplification and vibration patterns for conventional solid and damped laminated aluminum beams.

of equal static stiffness. However, resonant vibration control through a common design method like structural rigidization results in over design for static loads. With structural damping techniques, the structure's stiffness property need only meet static load requirements. Therefore structural damping techniques like the viscoelastic approach developed by Barry Controls can provide a lighter structure than the rigidized design.

Viscoelastic damping materials can be included in typical members (Fig. 1), such as structural sheet (panels and plate) and shapes (beams). There are also design methods, such as the use of strip dampers (Fig. 2), for adding damping to conventionally designed structures.

How viscoelastically damped structures control resonant structural vibration is shown by a comparison of the dynamic response characteristics of a damped, clamp-free (cantilever) beam with those of a conventional solid beam. In a typical test, an electrodynamic shaker imposes a sinusoidal vibration excitation to the beam support (Fig. 4).

The transmissibility, or vibration amplification factor, is defined as the ratio of the motion response at a specific point on the beam to the motion imposed at the support. If the beam response is measured at

the free end of the beam, the end-point transmissibility [$T(1)$] is given by:

$$T(1) = W(1)/a_0$$

The resonance amplification factor [$A_r(1)$] is the (maximum) value of the transmissibility that occurs at a beam resonance:

$$A_r(1) = T(1)_{max}$$

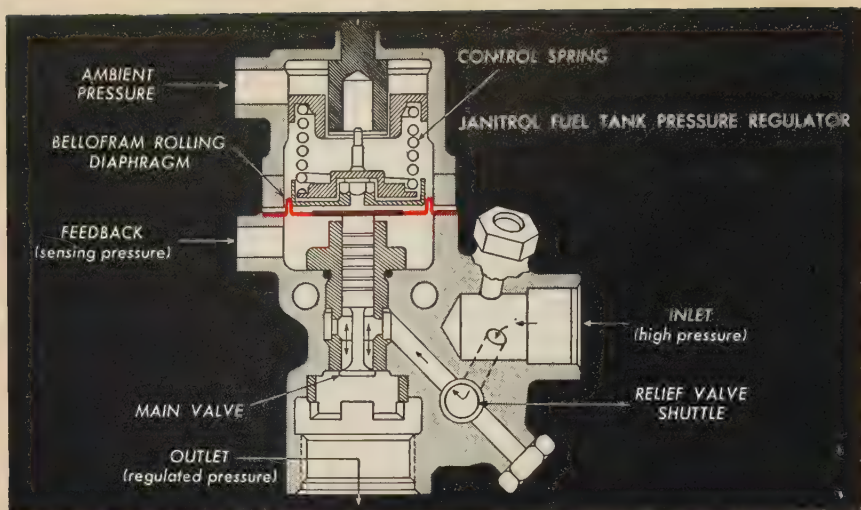
For structural vibration measurements, the bandwidth factor (Q) is usually defined as:

$Q = (f_n/\Delta f)\sqrt{(A_r^2 - A^2)/A^2}$, where f_n is the resonant frequency of the beam; A_r , the resonance amplification factor; and A , the vibration amplification factor at frequencies on either side of the resonant frequency for which the bandwidth of the resonance curve is Δf . While A_r depends on the particular position of measurement on the beam, Q is the same for all positions.

The damped beam greatly cuts vibration

$T(1)$ for a conventional and a damped laminated beam is shown in Figure 5 as a function of the ratio of excitation frequency (f) to the fundamental resonant frequency (f_1) of the beam. As we can see, the fundamental-mode resonance amplification factor for the damped aluminum beam has a value of 10—as against 300 for the conventional beam.

more on next page



In this Janitrol Aircraft fuel-tank pressure regulator, a drop in feedback (sensing) pressure allows combined force of ambient pressure and control spring to increase opening of main flow valve until system is again balanced in terms of ambient pressure. If ambient pressure drops with altitude, causing imbalance due to increased feedback pressure, frictionless Bellofram Rolling Diaphragm responds instantly to close valve. Write for free literature.

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PROBLEM To design a pressure regulator capable of stabilizing fuel-tank pressures in aircraft and missiles despite the following variables: (1) Altitude variations from sea level to 70,000 feet. (2) Compressor bleed air pressures from 12 to 250 psig. (3) Compressor bleed air temperatures from -65°F to $+350^{\circ}\text{F}$.

SOLUTION Janitrol Aircraft designers concluded that the key to their problem was to find a diaphragm or bellows of compact configuration that would respond instantly to minute variations in pressures. In addition, this device would have to be absolutely leakproof, vibration-proof, immune to aviation fuels and their vapors, and—most important—as friction-free as possible for maximum sensitivity.

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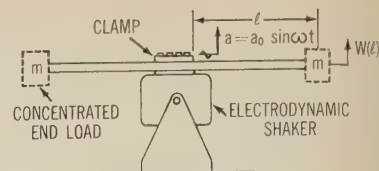


FIGURE 4: Setup for structural vibration tests.

The reduction of resonant vibration is even greater for the higher natural modes of the beam. The beam excitation is amplified by a factor greater than 100 for the first five modes of the conventional beam. The resonant peaks of the damped beam decrease at a rate of four decibels per octave, indicating that the higher modes of the beam vibration are heavily damped.

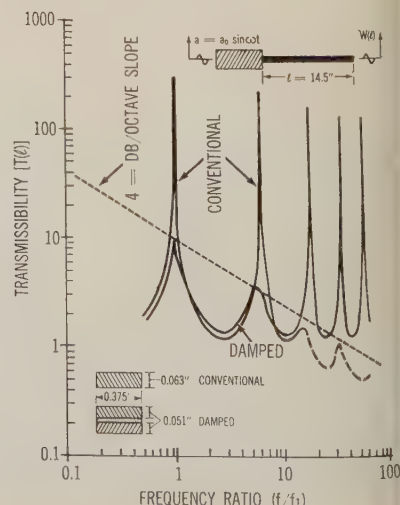
Figure 3 shows the vibration patterns for the first three modes of vibration for a conventional solid and a damped laminated beam with the same resonant frequencies.

Resonant vibrations of the damped beam are visible only for the lower natural modes, but the large vibration amplification is very obvious for all modes of the conventional beam.

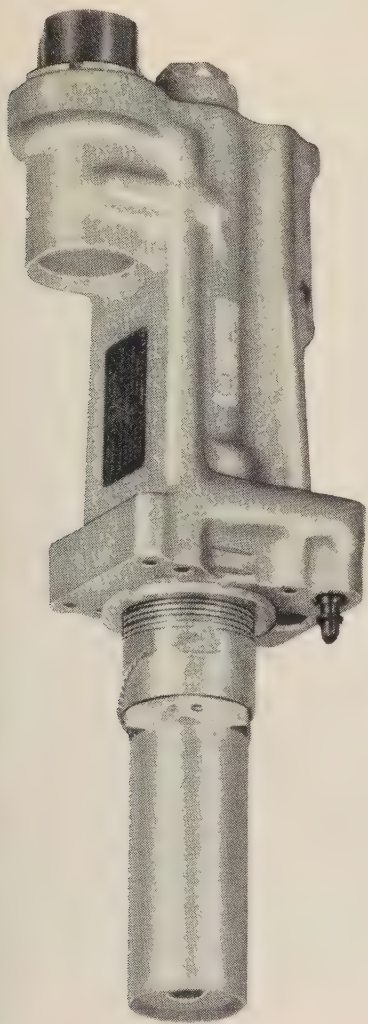
Figure 6 shows $A_r(1)$ for the fundamental modes of a conventional and a damped aluminum beam as a function of f_i and the input excitation displacement (a_0). The resonant frequency has little effect on $A_r(1)$ for the conventional beam,

more on page 66

FIGURE 5: Results of resonant-amplification tests with solid and damped aluminum beams where $2a_0$ equals 0.0025 in.; f_i , 10 cps; and $T(1) = W(1)/a_0$.



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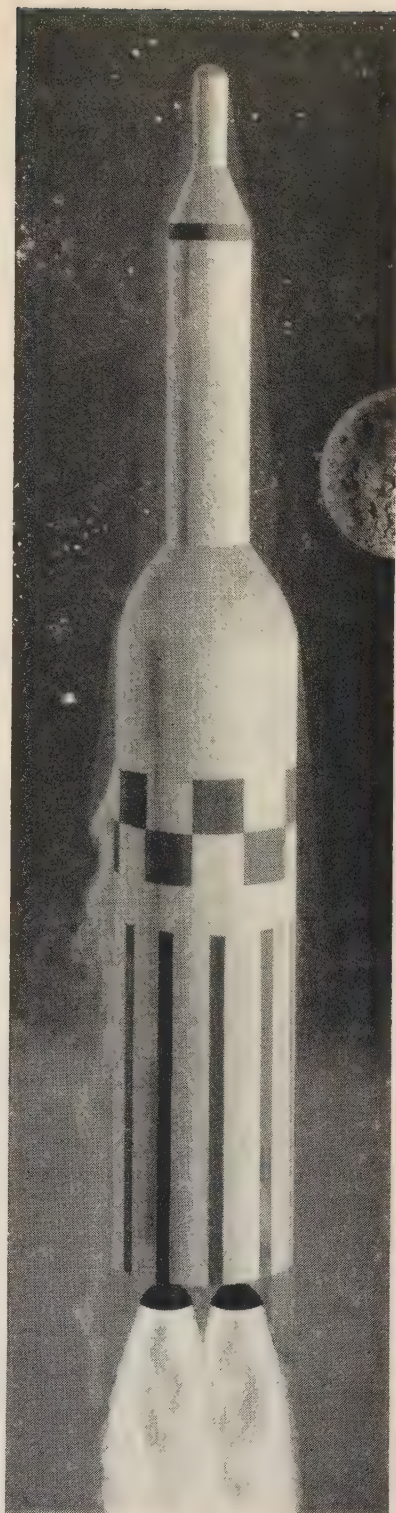
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Oklahoma City.....Service Supply, Inc.
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Philadelphia.....Frank W. Winne & Son, Inc.
Pittsburgh.....The Chatfield & Woods Co.
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DAMPING . . .

but a lower $A_r(1)$ value is obtained at the higher resonant frequency of the damped beam. $A_r(1)$ for the conventional beam varies between 300 and 80 for the test range of a_0 . For the same range, the damped beam shows nearly constant $A_r(1)$.

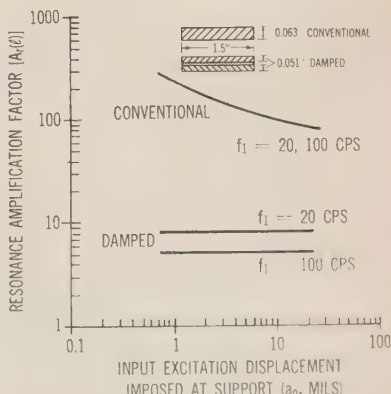
The difference in vibration amplification between a conventional and a damped structure shown in Figures 3, 5 & 6 also indicates the difference in stress levels induced in a structure at a given vibration excitation. The large resonant amplification associated with a conventional structure (with low structural damping) creates a relatively high resonant stress in the structure and so limits fatigue life. On the other hand, the low resonant amplification of a viscoelastically-damped structure creates a relatively low resonant stress and increases fatigue life. At sufficiently high structural damping, the fatigue life may be increased indefinitely.

Figure 7 shows the effect of extremely high and low temperatures on $A_r(1)$ for conventional and damped beams. The conventional aluminum beam has a constant $A_r(1)$ over the entire test temperature range. Typical curves for the damped beam show that $A_r(1)$ is greater at extremely high and low temperatures than at room temperature.

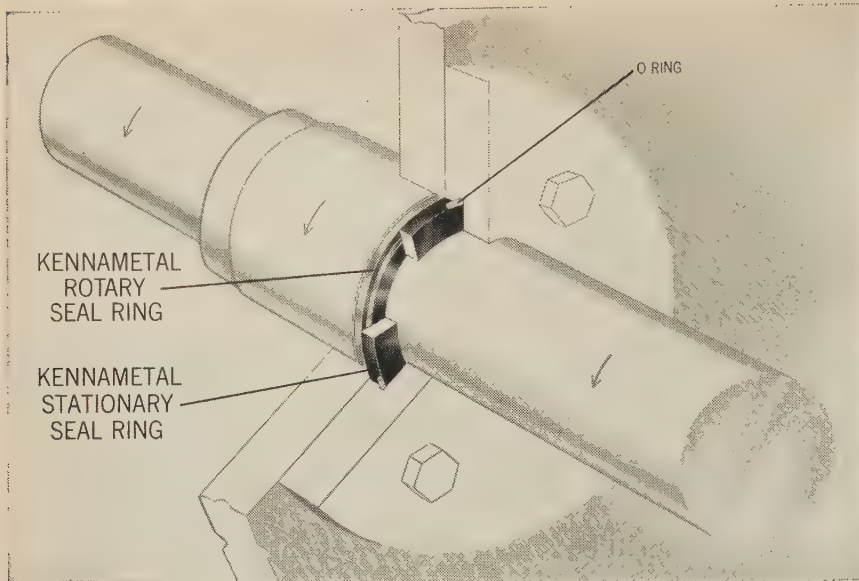
While the resonant vibration is limited to low values at room temperature, the viscoelastically damped beam is not as effectively damped at the temperature extremes. As we can see from Figure 7, the physical properties of viscoelastic damping materials depend on temperature.

more on next page

FIGURE 6: Comparison of $A_r(1)$ for the fundamental modes of conventional and damped clamp-free aluminum beams.



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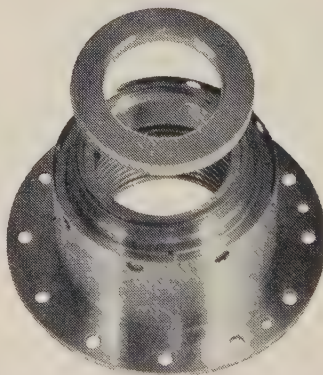
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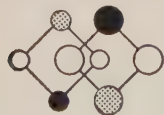
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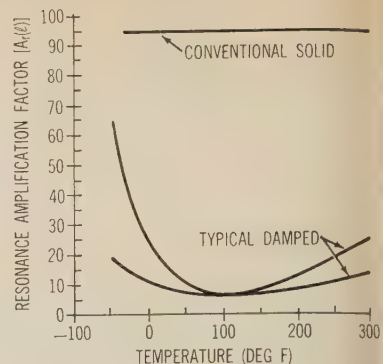


FIGURE 7: Effect of temperature on the damping properties of aluminum beams where a_0 equals 0.01 in. and f_1 equals 10 cps. The bottom curve is for a damped laminated beam using a silicone-based damping material. The damped laminated beams were subjected to various temperatures in an environmental chamber for 10 minutes, after which $A_r(1)$ for the fundamental mode was measured.

Figure 8 shows the effect of structural damping on the performance of a vibration isolation system in terms of absolute transmissibility (the ratio of the vibration response at the center of a free-free beam to the vibration imposed at the support) as a function of the ratio of f to the rigid-body natural frequency (f_0). The curve for material damping represents the response obtained for a solid steel beam; at the fundamental resonant frequency of the beam, the transmissibility is over 800 times higher than that for a rigid beam. For a riveted, laminated steel beam, the transmissibility is over 30 times higher than for a rigid beam at the fundamental resonant frequency. For a viscoelastically damped, laminated steel beam, the transmissibility is 10 times higher than that for a rigid beam at the fundamental resonant frequency.

While the riveted structure is an improvement over the solid one, the best control of resonant structural vibration is obtained with viscoelastic damping. The mean high frequency of all damped beams, regardless of the amount of damping, has an attenuation rate that is less than that of the rigid-body response. Thus structural resonance, whether highly damped or not, reduces the overall high frequency isolation of a vibration isolation system.

more on page 71

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SPACE/AERONAUTICS

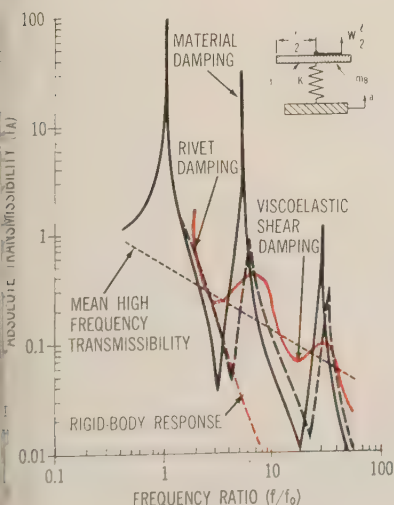
The variation of transmissibility above and below the mean high frequency transmissibility line, as caused by structural resonances and anti-resonances, is reduced if energy-dissipating mechanisms are used in structural fabrication. Viscoelastic-shear damping mechanisms provide the best resonant vibration control without such disadvantages as non-linear damping and surface fretting, which occur with the dry-friction damping mechanism of riveted joints.

Figure 9 shows $T(f)$ for solid and cell-insert damped I-beams as a function of f/f_0 . The beams are tested as double clamp-free beams with no concentrated end weights attached. At the fundamental resonant frequency, vibration amplification is 15 times greater for the solid beam vibration than for the damped beam. At the second-mode resonant frequency, the solid beam amplifies the excitation more than 40 times as much as the damped beam.

Comparison of $A_r(f)$ for the fundamental mode for the solid and cell-insert I-beams as a function of

more on next page

FIGURE 8: Effect of structural damping on the performance of a vibration isolation system where f_0 equals $0.5\pi\sqrt{K/m_B}$; f_1/f_0 , 5; and $T_A = W(1/2)/a$. The idealized test model consists of a non-rigid structure in the form of a free-free beam supported at its center by a simple spring isolator. A sinusoidal vibration excitation is imposed at the rigid support to which the spring is attached. Material damping response is characteristic of a welded design; rivet response, of a riveted or bolted assembly.



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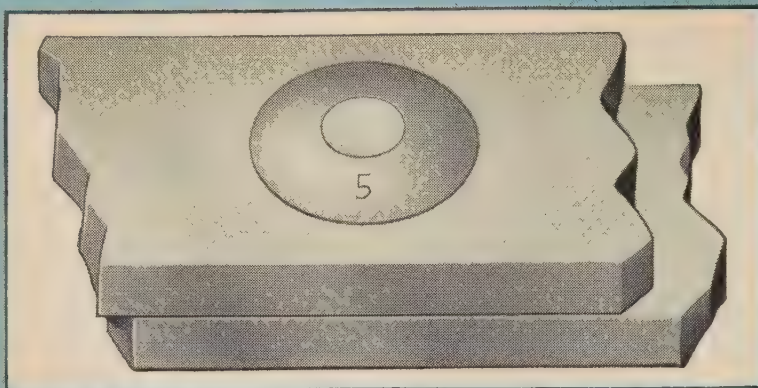
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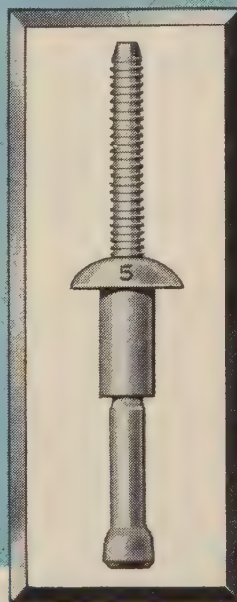


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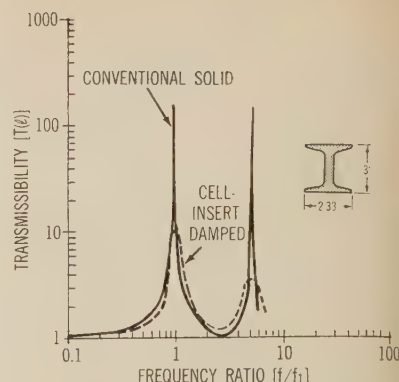
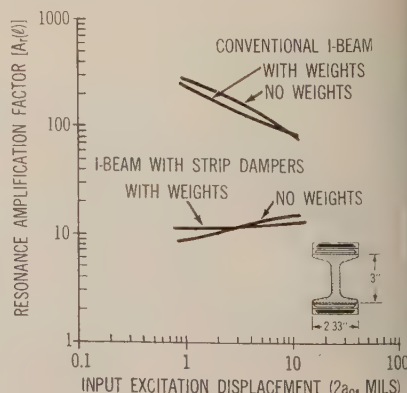


FIGURE 9: Comparison of end-point transmissibility of clamp-free solid and cell-insert damped I-beams.

the excitation displacement imposed at the support shows that $A_r(1)$ for the solid beam varies between 300 and 80 over the test range of excitation levels. The cell-insert damped beam shows values of $A_r(1)$ of less than 10, which are nearly constant for all test levels of vibration. The cell-insert design has very linear damping properties, in contrast to those of the conventional solid beam.

Figure 10 shows $A_r(1)$ for the fundamental mode of vibration of I-beams with and without strip dampers as a function of the excitation displacement of the support. The strip damper, which has a continuous retainer and the cross-section shown in Figure 2, is attached continuously along the entire double length of the standard three-inch aluminum I-beam. As shown, the strip dampers greatly reduce resonant vibration amplification. Write in No. 73 on Reader-Service Card for more information.—End

FIGURE 10: Effect of strip dampers on beam damping properties.



SPACE/AERONAUTICS

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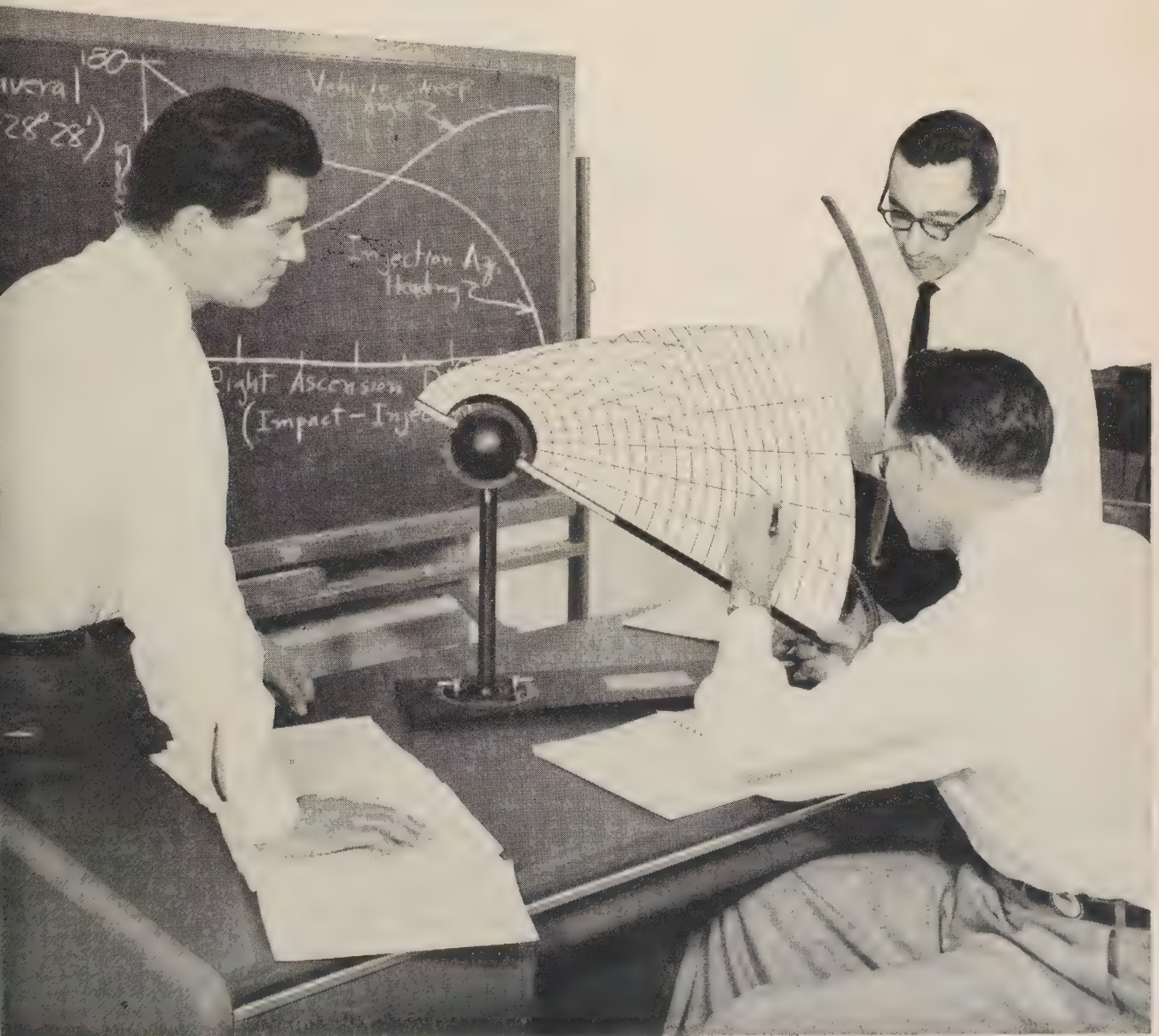
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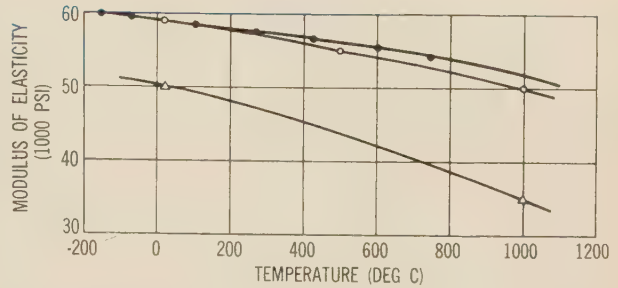
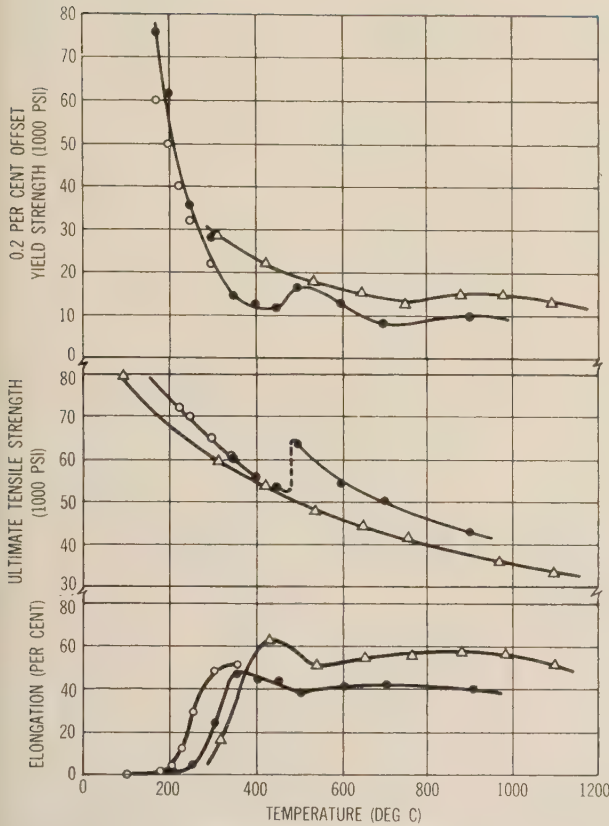
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TEMPERATURE vs modulus of elasticity for tungsten as given by Stanford Research Institute from data by Koster (bullets), Fansteel (circles), and Toensing (triangles).

◀ **TENSILE** properties of tungsten vs temperature as given by Stanford Research Institute from data by Bechtold and Shewmon for 0.00028-in./in./sec strain rate and 1/2-hour anneal at 1900 deg C in H_2 (bullets), Bechtold for 0.00028-in./in./sec strain rate and one-hour anneal at 2000 deg C in a vacuum (circles), and Pugh for 0.003-in./in./sec strain rate and one-hour anneal at 1800 deg C in H_2 .

Tungsten plating made easy by vapor deposition

In a little over a year, a series of significant breakthroughs has been achieved in tungsten fabrication. The latest is a simple vapor deposition method for plating tungsten on metal surfaces.

A CONTINUING series of breakthroughs in tungsten technology has raised hopes that this metal may go a long way toward meeting the extreme temperature demands of vehicles now on the drawing boards. The key problem, of course, has been fabrication. The basic natural hardness of tungsten (about 40 R_C) is indeed hard to get around. The situation is somewhat the same as

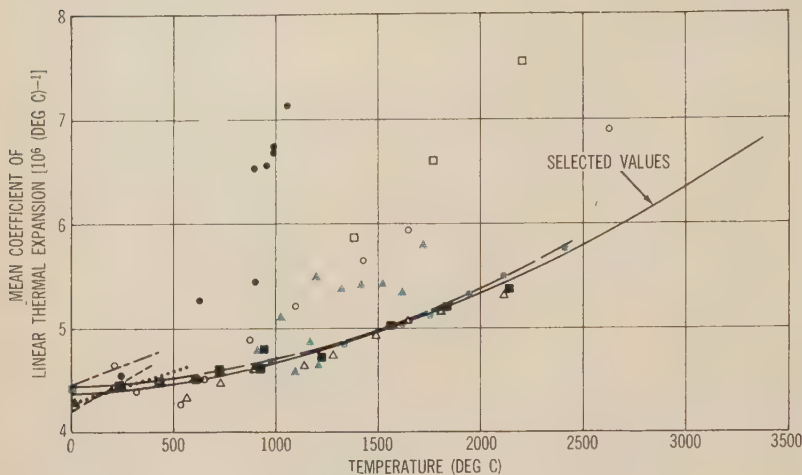
with 4150 hardened gun barrel steel, but the steel is still easier to machine.

Nevertheless, amazing progress has been made in the development of tungsten forming methods for deep-drawing, forging, etc. For more complex shapes, flame deposition methods have been developed. (See *S/A*, "New Tungsten Know-How Widens Design Hori-

zons" & "Plasma Arc Process Coats and Forms Refractory Materials," July '59, pp. 48 & 105.)

The latest advance has been the development of a vapor deposition process for plating highly pure tungsten on metal surfaces. Devised for the Navy by W. E. Reid and Dr. A. Brenner of the Electrodeposition Group at the National Bureau of Standards, Washington 25, D. C., the method involves the reduction of gaseous tungsten hexafluoride (WF_6) with hydrogen by passing it over the heated object to be plated. At temperatures above 300

more on next page



THERMAL expansion of tungsten as given by Stanford Research Institute from data by Fink (black triangles); Worthing (blue bullets and long dashes); Gray, Schad, and Hidnert (short dashes); Disch (long and short dashes); Goucher (black squares); Berlin (blue triangles); Hidnert and Sweeney (dots); Becker (open squares); Shinoda (black bullets); Nix and MacNair (blue squares); Demarquay (open triangles); and Appleby and Pellini (circles).

deg C, tungsten is deposited on the hot surface; the only other reaction product, hydrogen fluoride, passes out with the excess of hydrogen.

A major advantage of this approach, NBS states, is that the tungsten obtained with it is purer than ordinary commercial tungsten. Spectrochemical examination, researchers report, shows that silicon is the only impurity present in a concentration of 0.1 per cent or more. In addition, they state, the deposited metal has the theoretical density of pure tungsten (19.3 gm/cm^3), which is higher than that of the tungsten compacts produced by powder metallurgy or flame spraying. The reason for this, it's stated, is that plating eliminates the very tiny holes between tungsten particles resulting from the other two processes.

The process is free from side reactions

The hardness of the deposits obtained at 650 deg C, NBS says, is about 475 VHN, or about that of ordinary commercial tungsten. The crystals deposited at 900 deg C are not as hard (410 VHN), indicating a slightly higher degree of purity.

WF_6 was selected for NBS's

method for two reasons: (1) It is gaseous at room temperature and thus easy to use. (2) WF_6 apparently is the only compound tungsten forms with fluorine. The reactions therefore are straightforward, NBS states, and you avoid the complications of several products or of side reactions.

Another advantage claimed by NBS is that only simple equipment is needed. The object to be plated is placed inside a cylinder of ceramic material, and the air is evacuated and replaced with hydrogen. The part is then heated to about 650 deg C by a controlled-temperature induction furnace.

Wide process variations are allowed

At this point WF_6 and hydrogen are passed into the reaction chamber through ordinary glass flow meters. When they come in contact with the part, tungsten is deposited on the hot surface. The byproduct of this reaction, hydrogen fluoride, is absorbed in a suitable trap.

Even though the theoretical ratio of three moles of hydrogen to one mole of hexafluoride is needed for

more on page 78

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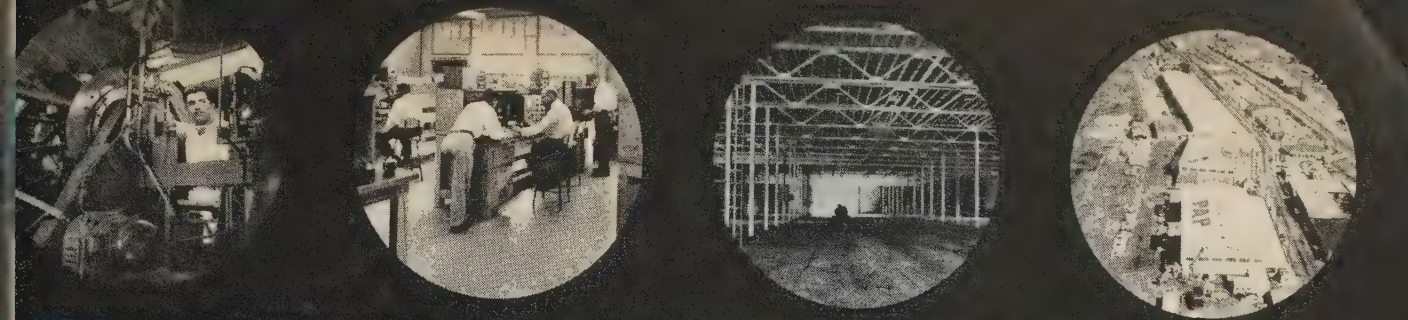
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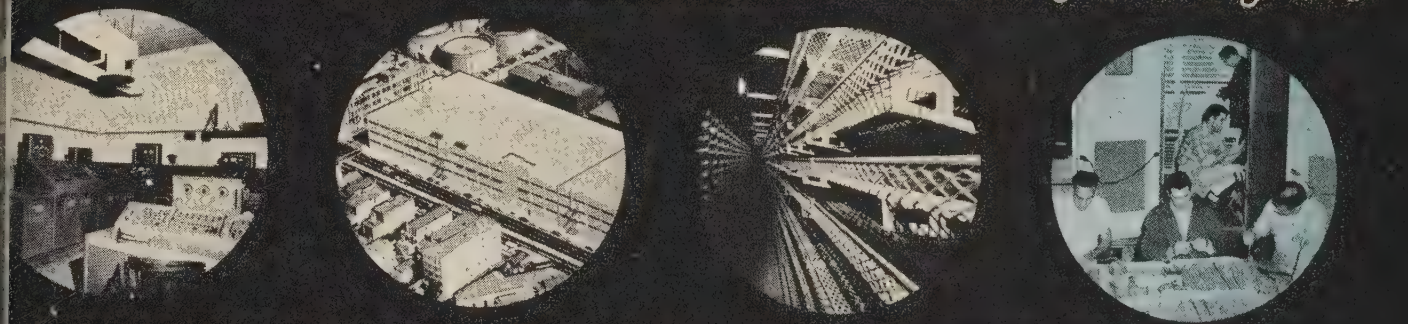
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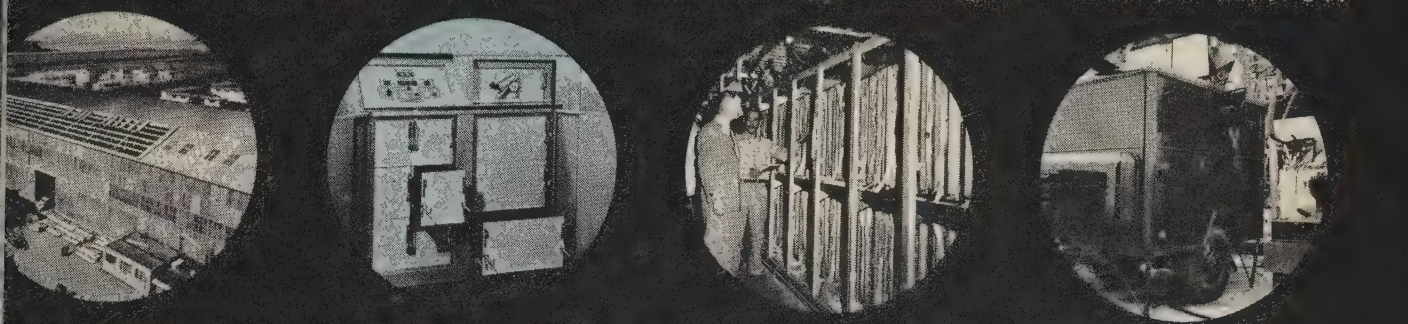
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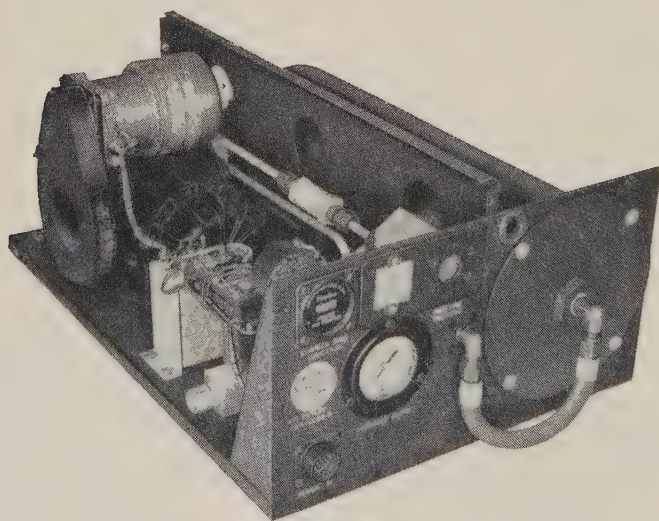
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Thermal Conductivity of Tungsten

Temperature (deg C)	Thermal Conductivity (cal/cm ² /sec/deg C/cm)	
	Forsythe & Worthing	Osborn
20		0.31
727	0.200	
827	0.186	0.278
927	0.215	0.275
1027	0.222	0.271
1127	0.230	0.268
1227	0.236	0.263
1327	0.243	0.260
1427	0.247	0.256
1527	0.255	0.253
1627	0.260	0.248
1727	0.264	0.245
1827	0.269	
1927	0.273	
2027	0.278	
2127	0.283	
2227	0.287	
2327	0.292	

complete reduction, says NBS, satisfactory coatings are also obtained when the ratio is lower. In practice, smooth variations are insured by a hydrogen-hexafluoride ratio greater than 6.

Wide variations in the flow rate of the gases and in the pressure in the system have no major effect on either process efficiency or coating quality, NBS states. Although the optimum temperature range for rapid formation of smooth deposits is 650-700 deg C, temperatures from 300 to nearly 900 deg C are fairly effective. Definite crystal growth is observed at 900 deg C when the ratio of hydrogen to hexafluoride lies between 3 and 4.

Adhesive bonds were studied in NBS program

In the NBS program, the adhesive bond between the tungsten coatings and various basic materials was studied. Adhesion to molybdenum, iron, and various ceramics was good. The tungsten-graphite bond was about as strong as the graphite itself. With copper, adhesion was somewhat weaker.

more on page 80

RTV (room temperature vulcanizing) silicone rubber being applied as sealant in Douglas DC-8. RTV cures without application of heat; won't shrink (no solvents); forms no voids. It has excellent bond strength, plus resistance to high temperatures, moisture, weathering, ozone, aircraft fuels and solvents.

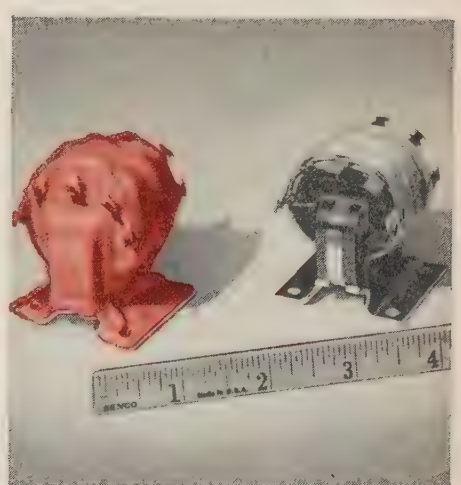
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Prototype jet engine nose cone (right) cast in RTV mold. Epoxy parts cast in flexible RTV molds have a bright, glossy surface and reproduce extremely fine detail. No parting agent is required for even the most complex parts. High tensile and tear strength is retained even after prolonged heat aging.



Close-tolerance, non-standard helix gear cast complete in low-cost, one-piece RTV mold. Previously such replacement parts had to be machined by hand. Now they can be quickly and inexpensively replaced by using the broken part as a master.



Potting and encapsulating of electrical components, such as this aircraft transformer, are easy with RTV. It can be poured, sprayed, painted or applied by dipping. Temperature resistant from -60°F to $+600^{\circ}\text{F}$; excellent resistance to high altitude arc-over and corona. Comes in wide viscosity range.

For application data and samples of General Electric RTV silicone rubber, write to General Electric Company, Silicone Products Department, Section 142 Waterford, N. Y.

GENERAL  ELECTRIC

Silicone Products Dept., Waterford, N. Y.

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than with molybdenum.

Tungsten manufacturers point out that designers would be wise to check with them before using tungsten for plating. Metallurgical changes can occur in bond areas, they point out. For example, if tungsten is used with graphite in high temperature areas, the tungsten could react to form tungsten carbide, a material with a lower melting point than tungsten.

Because tungsten has never been deposited from either aqueous or

organic solutions. NBS found it necessary to evaluate deposition from both fused electrolytes and the gaseous phase. In the former case, the plating rate was too low, the deposit too rough, and the coatings couldn't be built up to the desired thickness.

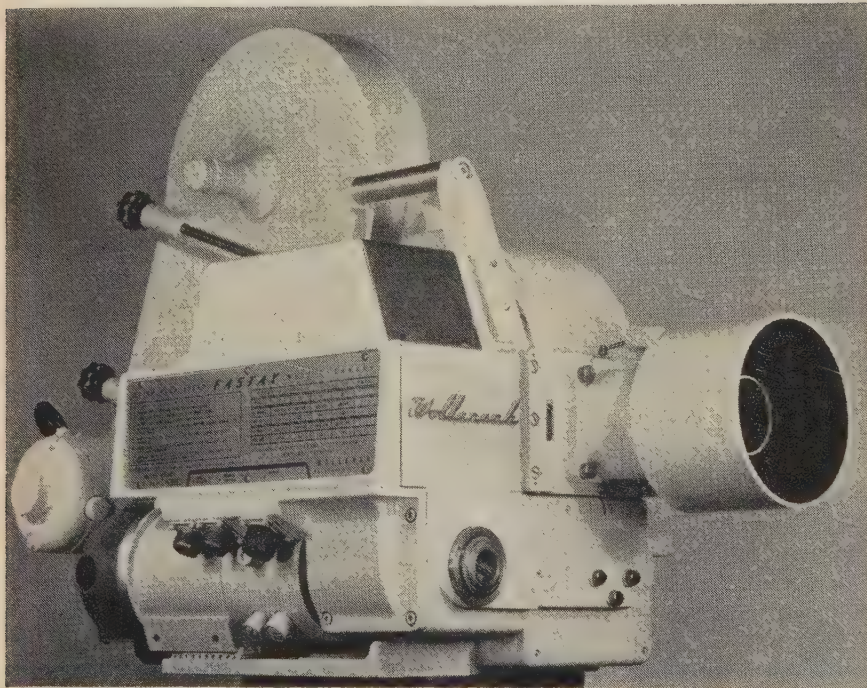
With the vapor deposition method, $\frac{1}{16}$ -in.-thick deposits were obtained in an hour. In the same time, only 0.001-in. thicknesses were obtained with fused electrolytes. NBS hasn't yet found the

maximum deposit thickness afforded by the vapor method, which depends on the permissible surface roughness. Because of its deposition speed, says NBS, the vapor process lends itself to the continuous production of tungsten-coated strips or wires.

Deposition problems with tungsten remain

It's simple to plate a strip or wire, researchers note, but the uniform deposition of tungsten over an irregularly shaped object is a problem that must be solved separately for each item. Deposition is more uniform over the exterior of an object, they point out, if the plating is done in a chamber much larger than the object. As tungsten deposition occurs in the greatest quantity where the gases first strike the hot part, better distribution can probably be obtained by passing hydrogen through the main opening in the chamber and using a series of injector tubes to lead the WF_6 to various areas of the part.

The new method makes it possible to coat a wide range of rocket nozzles, jet engine parts, etc., NBS states. It can also be used for making tungsten parts and, in fact, may offer the only way of forming complicated shapes. For such parts, a metal form is used that is chemically dissolved after deposition. Simple tungsten shapes for vacuum tubes have already been made.—IS



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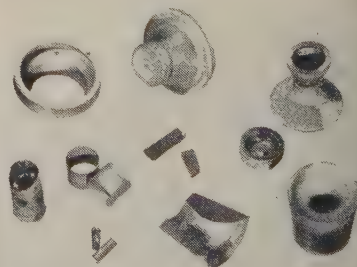
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SAMPLE PLATED parts include a rocket nozzle (bottom right), a nozzle shown in cross-section (bottom center), and rectangular parts (center). Items made entirely of tungsten include an electron furnace (top left & center), a thick rocket nozzle insert (top right), sample tubing (left center & bottom), and a crucible (right center). The excellent covering ability of the process is shown by the completely coated interior and exterior of the object at left center.



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SPACE/AERONAUTICS



DOUGLAS SELECTS BENDIX BRAKES FOR THE DC-8

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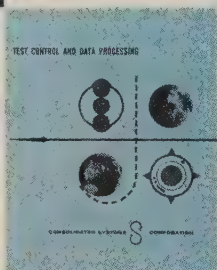
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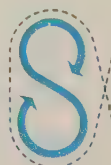
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SPACE/AERONAUTICS



Testing full-scale fuel tanks

WHIFFLETREE load system used on the forward wing tank.

A rigorous test program was set up for F-106 tanks for production qualification: Filled full-scale tanks were subjected to a complete spectrum of fatigue loading under closely simulated environmental flight conditions.

by **James K. Neary**, Test Engineer, Convair-San Diego*

IN THE Convair F-106 interceptor, the plane's nine fuel tanks are integral parts of the structure. To meet the high strength requirements without undue weight increases, we use machine-sculptured and integrally stiffened skins in these tanks. The skins are riveted and bonded to the supporting structure with Minnesota Mining & Mfg.

EC-1290 Scotchweld adhesive.

For qualification for production aircraft, full-scale F-106 tanks were put through a complete test spectrum of fatigue loading under environmental flight conditions. Load, pressure, temperatures, and transient heat rates were applied in combination to simulate flight conditions. All tanks were tested while filled with JP-4 fuel to determine the effect on the Scotchweld bond

under repeated load and temperature variations.

The test program was divided into three phases, each run at sub-zero, ambient, and elevated temperatures:

- static load and pressure;
- statically applied repeated load and pressure cycling;
- dynamic loading at the natural resonant frequency of the structure.

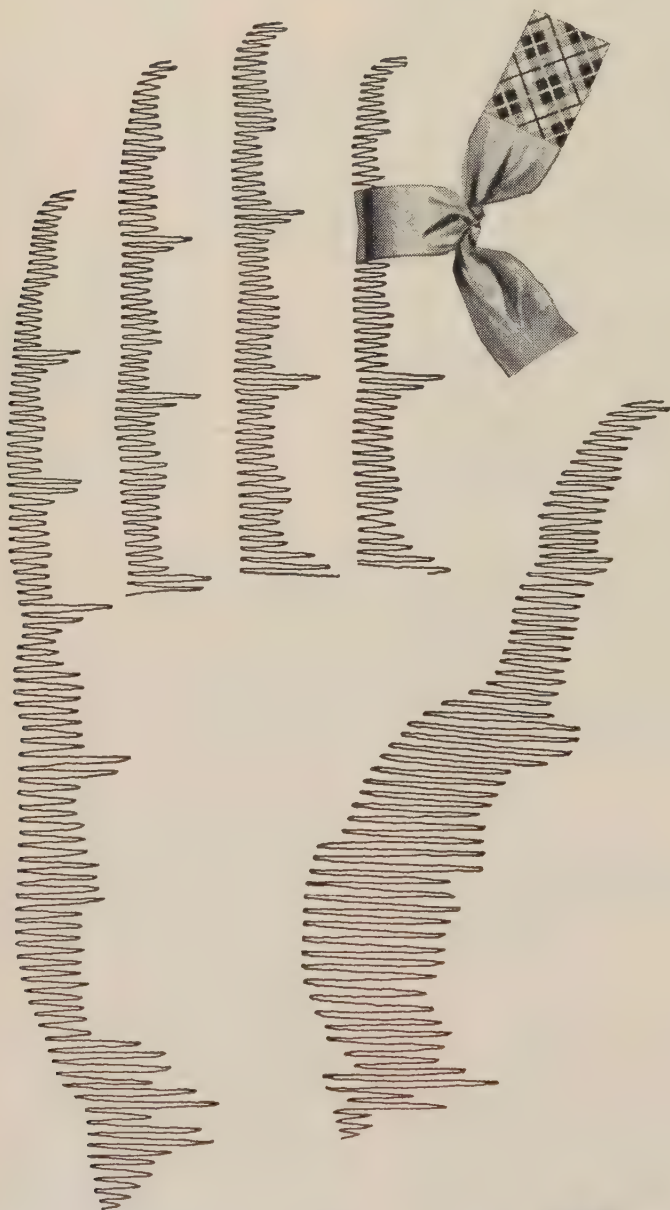
Design criteria could be verified during simulated flight loading — strain, deflection, and permanent set, as well as thermal gradients throughout the structure during transient heating. In addition, a complete fatigue study was made of the tank structure, the integrally stiffened skin, and bonded areas.

more on page 85

*Convair Div., General Dynamics Corp., 3165 Pacific Highway, San Diego 12, Calif.

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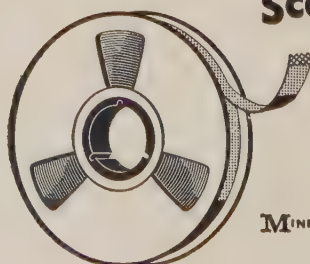
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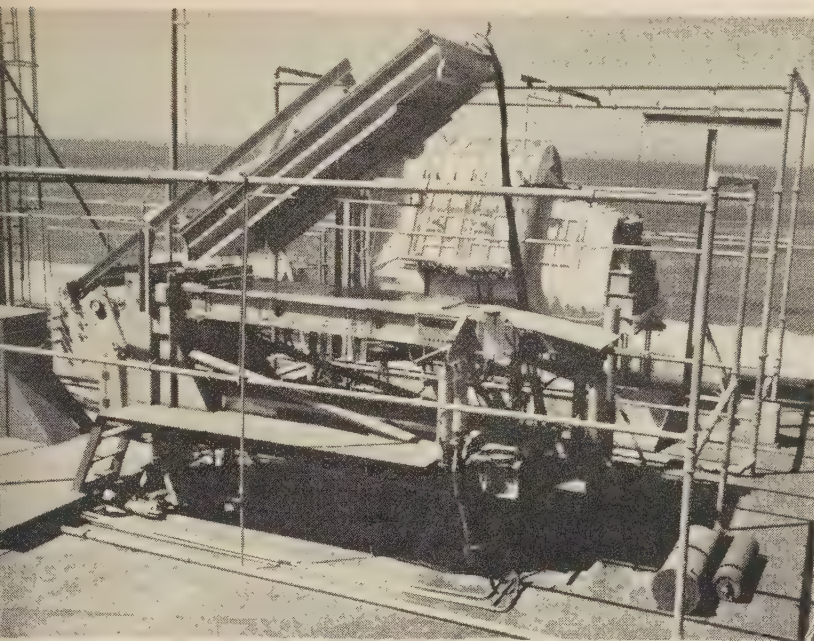


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SPACE/AERONAUTICS



TEST SETUP for the wing transfer tank.

The four specimens tested in this series were the F-106A fuselage tank, the F-106B fuselage tank, the wing transfer tank, and the forward wing tank (Fig. 1). All were mounted in the normal horizontal position on self-reacting steel jigs. The fuselage tanks were built as part of a production fuselage section to reproduce the load carry-through into the tank that occurs in actual flight.

During the ambient- and sub-zero-temperatures test phases, load was applied to the wing transfer and fuselage tanks through a steel end fixture by hydraulic actuators and to the forward wing tank by tension and compression pads bonded to the skin surface. A hiffletree system distributed air and inertia loads over the wing surface to produce a test moment and shear in the tank structure similar to those occurring in flight. The integrally stiffened top and bottom skins were attached to the supporting jig through a hat-section-type ring to simulate the flexural strength of the fuselage. In all tests, the JP-4 fuel was run through the tanks by an 80-gpm pump.

The sequence of applied-load and internal fuel pressure cycles was controlled automatically by an electronic repeat-cycle mechanism. During the final phase of testing, the fuel tanks were loaded at their natural resonant frequency. The load to overcome the natural damping of the structure was applied by

a motor-driven, eccentrically loaded flywheel. Both motor and flywheel were attached to the end fixture.

Throughout this dynamic loading test, fuel at critical flight pressure and temperature (ambient and sub-zero) was circulated through the test specimen. Applied load was monitored by strain gages mounted on the tank structure.

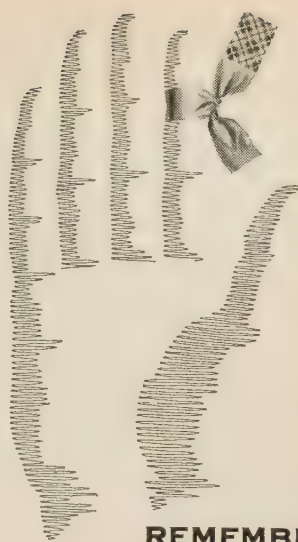
To simulate sub-zero conditions, fuel was cooled in a remotely located sump tank by the direct addition of liquid carbon dioxide. The cooled fuel was pumped through the specimen at test pressure, the fuel flow being controlled to keep the specimen at -65°F at all times. As we used a fuel back pressure valve, the sub-zero fuel could be pumped continuously through the specimen.

Surfaces were painted for maximum absorption

During the high temperature tests, the external surfaces of the tanks, which would be heated aerodynamically in flight, were painted a dull black for maximum heat absorption. Heat was applied by 2500-W tubular infrared lamps installed at two-inch centers. The lamps were mounted on aluminum clamshell-type reflectors designed for maximum heat distribution.

During the actual test, the reflectors were lowered to bring the infrared lamps to within six inches of

more on next page



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TESTING TANKS . . .



INFRARED lamp bank used on forward wing tank in high temperature tests.

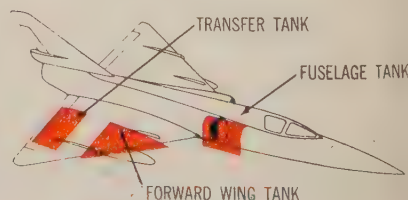
the specimen surface. The temperature of the thinnest section of the machined-sculptured integrally stiffened skins was increased from ambient to 216 deg F (at the critical rate of 10 deg F sec) to simulate aerodynamic heating.

The fuel in the specimen was kept at the flight level and cooled with CO₂. This cooling of the fuel and therefore of the tank structure during transient heating produced high thermal stresses in the skin. The power to the heat lamps needed for the correct heat rate during transient heating and the correct steady-state high temperature during repeated load cycling was controlled by a General Electric saturable reactor system. During transient heating, this system programmed the heat input as a time-temperature function.

Iron-constantan, split-peened thermocouples measured the temperature throughout the specimen. During transient heating, about 50 thermocouple readings were recorded simultaneously on an oscillograph. From these test data we determined the thermal gradient through the heated skin and Scotch-weld bond and into the supporting structure. Strategically located strain gage readings also were recorded oscillographically to determine the magnitude of thermal strain during transient heating. Permanent set and deflection of the tank structure as well as local deflection and set

more on page 88

FIGURE 1: Location of fuel tanks on the F-106.



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The Model GSA-10 *Stratosair* offers airline and military operators today's most economical and effective means of providing a continuous ground air supply for turbojet and turboprop aircraft. Heart of the *Stratosair* is a unique Heli-Rotor compressor that provides the output required for engine starting for any current aircraft. The unit also can provide warm air for deicing and a continuous supply of air for air conditioning, heating and check out of pneumatic systems.

The Heli-Rotor combines the non-surge characteristics of a positive displacement compressor with the high delivery rate at low weight and small size of high speed aerodynamic machines.

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The illustration shows the Heli-Rotor pack mounted on a standard International 1½-ton truck. It can be provided on a skid mount, on a simple trailer mount or mounted on any of a variety of suitable trucks.

The compressor drive is an International UV549

V-8 engine. The engine-compressor

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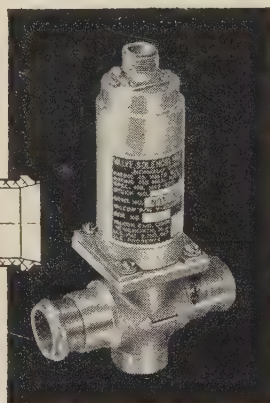
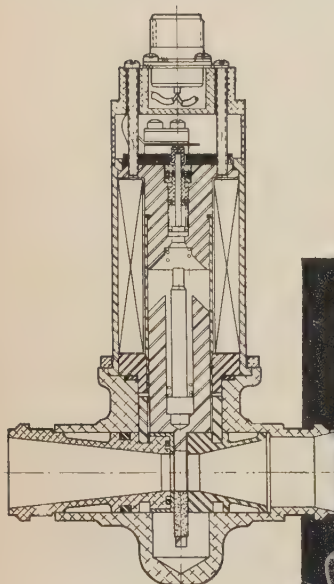
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KENILWORTH, N. J.—An entirely new direct acting venturi-type valve, in a 1" line size, yet weighing only 1¾ lbs., has been announced by Valcor Engineering Corp.

The valve combines an efficient venturi plus Valcor's patented, optically flat floating seal principle to insure a straight-through flow path without obstructions. The pressure recovery characteristics of the venturi allow the reduction of the inside diameter of the fluid line to a relatively small throat; this permits the use of a minimum weight, direct acting solenoid. The self-lapping, floating seal disc, with its self-cleaning action withstands normal contaminants and foreign matter. The combination of the efficient venturi, the floating disc, and the direct acting design produces maximum reliability.

Only high temperature insulating materials are used: teflon, silicone and glass. The coils are unaffected by mechanical and thermal shock, and maintain dielectric strength under salt spray, temperatures to 500°F and other adverse environmental conditions. Both valve and solenoid are rated from zero to 255 psi, over an ambient temperature range of -65°F to +250°F, with fluid temperatures between -30°F and +350°F—and up to 550°F for a maximum of 10 minutes.

Ports are constructed in accordance with military standard fittings AND 10058-16. The valve is easily adaptable to any type of fitting.

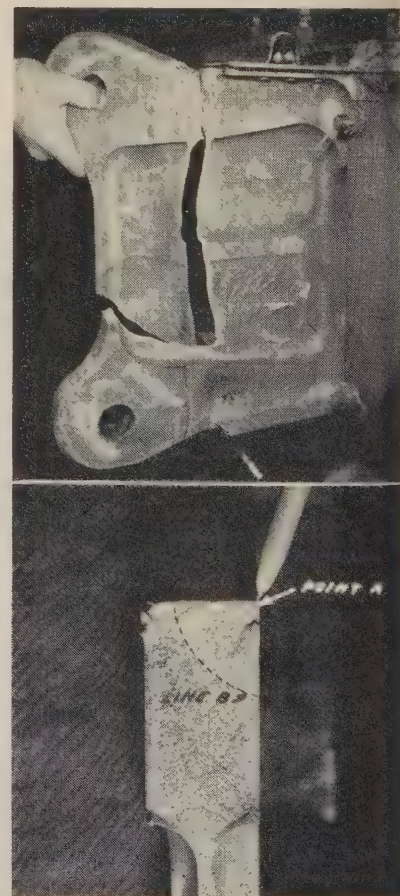
Further information, including technical literature on the new Model V-20000-04 venturi-type solenoid valve, is available from **VALCOR ENGINEERING CORP., Kenilworth, New Jersey.**

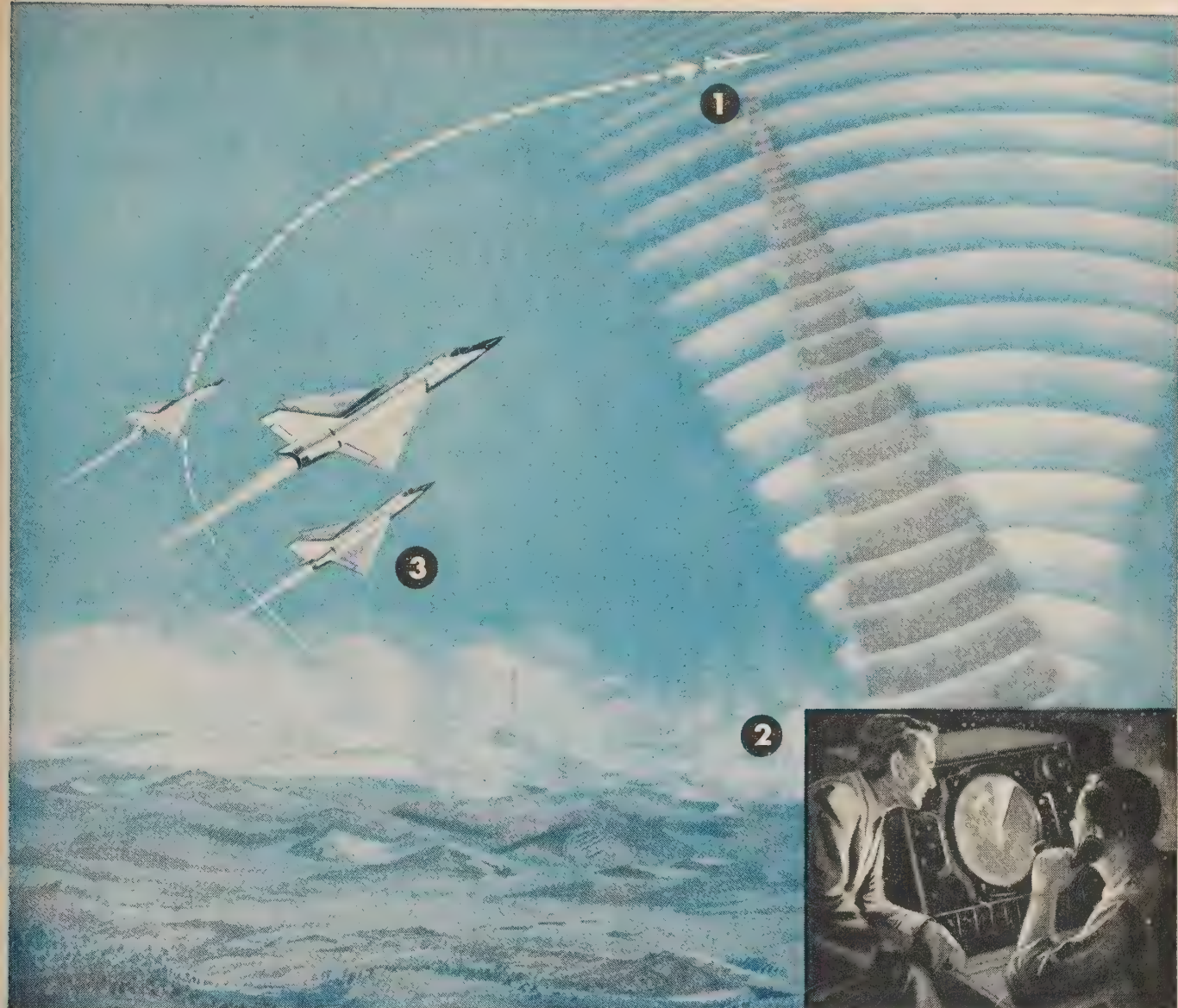
in the integrally stiffened skin were measured by calibrated deflection beams and linear transducers.

All three fuel tanks stood up successfully under the complete spectrum of repeated load qualification tests. However, repeated loading was continued until failure occurred in order to determine the actual fatigue life of the structure.

Failure in the form of fatigue cracks usually showed in slight fuel leakage in the areas of high stress concentration. In the case of the forward wing tank, a fatigue crack resulted in the complete failure of the wing spar (Fig. 2). The origin of the failure was a fatigue crack propagating from point A and progressing to point B. When the fatigue crack reached line B, the cross-sectional area of the spar was reduced so much that a static failure occurred. The evaluation of strain gage data confirmed this failure sequence.—End

FIGURE 2: Fatigue crack that resulted in complete failure of the wing spar during testing of the forward wing tank propagated from point A and progressed to line B.

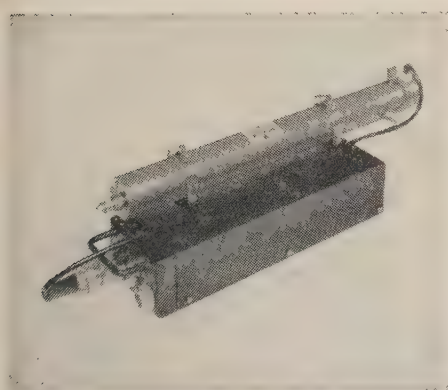




(1) Drone flies at speeds of Mach 2 and beyond, and at altitudes greater than 50,000 feet. Pulse from ground radar is detected by drone's SEE system, which "enhances" the pulse and retransmits it (2) to radar station. Much larger "pip" is seen on radarscope than drone would

ordinarily make. Size of picture can be adjusted to suit the particular military exercise. Radar operator dispatches fighters or missiles (3) which intercept and "kill" drone.

How drones "stand in" for giant bombers and missiles



KEY COMPONENTS in SEE system are Sperry Traveling Wave Tube Amplifier, and compact power package. Total weight: less than 20 pounds.

For testing the nation's defenses, a unique electronic system—named SEE for Sperry Echo Enhancer—makes miniature target drones look like intercontinental bombers or missiles.

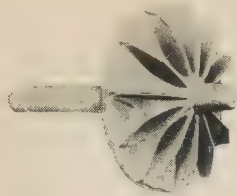
SEE is a simple and inexpensive method of doing this vital job. Weighing less than 20 pounds, it consists of a traveling wave tube developed by Sperry's Electronic Tube Division, plus a miniaturized power "package" and antennas. By means of simple antennas, the equipment receives signals from ground radars, returns these signals with greater intensity to ground radarscopes. "Pips" of any desired size can be created.

Extensively flight-tested at Cape Canaveral, SEE has had broad acceptance by the military services and is being delivered also to defense contractors and friendly foreign governments. Designed for use with either surveillance, air-intercept or tracking radars, it is also applicable to ground control since it can be used in locating and tracking aircraft with great accuracy and over long ranges.

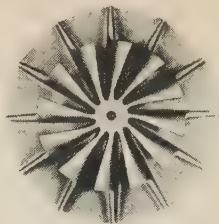
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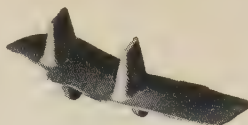
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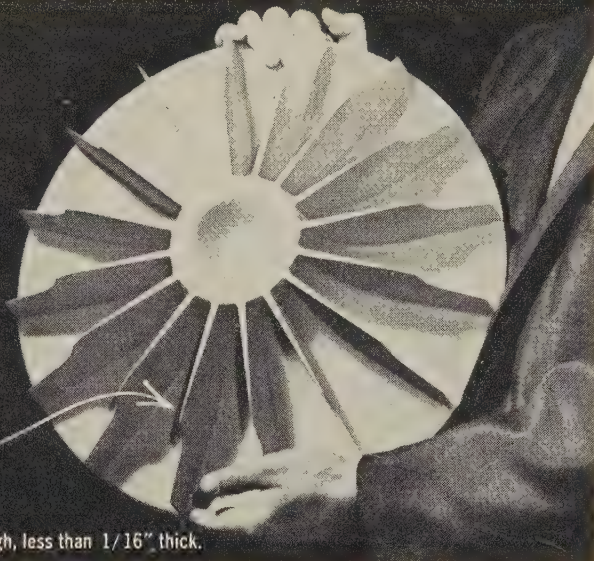


Precision turbine wheel is one-piece Arcturus forging.



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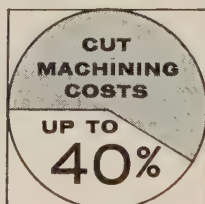


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books

The Encyclopedic Dictionary of Electronics and Nuclear Engineering, by Dr. R. I. Sarbacher. This comprehensive reference work encompasses some 14,000 entries of definitions, equipments, elements, components and systems in these two fields. Over 1400 illustrations and 17,000 cross-references are included. Under the word "antenna," for instance, there are 206 entries and 92 illustrations. Prentice-Hall, Inc., 70 Fifth Ave., New York 11, N.Y. \$35.

Solution of Problems in Aerodynamics, by S. A. Urry. Intended as a supplement to lecture notes, this book contains 400 problems with detailed solutions for over half and answers for the remainder. Pitman Publishing Co., 2 W. 45th St., New York, N.Y. \$6.75.

German Secret Weapons of World War II, by Rudolf Lusar. Although this book deals with all types of weapons, down to rifles and field pieces, a good portion of it is devoted to advanced German work in missiles, aircraft and airborne armament. Philosophical Library, Inc., 15 E. 40th St., New York 16, N.Y. \$10.

Servo Engineer's Handbook. Written by engineers of Daystrom Transicoil Div., this is intended as a practical aid for the servo engineer in his day to day work. Instrument type servomechanisms, considered to be those which operate at a load power of under 25 W. Basic circuit diagrams, pertinent equations, etc., are presented. Daystrom Transicoil, Div. of Daystrom, Inc., Worcester, Montgomery County, Pa. \$3.

Turbulent Flows and Heat Transfer, edited by C. C. Lin. This volume presents the principal approaches to our present understanding of turbulent flows, with consideration given to both skin friction and the interrelated problem of heat transfer. Subjects covered include the transition from laminar to turbulent flow; turbulent flow; statistical theories of turbulence; convective heat transfer, etc. Princeton Univ. Press, Princeton, N.J. \$15.

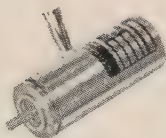
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SPACE/AERONAUTICS

Shock strut valve halves pulse loads

You can't do much with conventional shock struts when you are trying to reduce landing gear loads. What you can do, however, is to make a simple valve mod in the strut.

by **Emanuel Schnitzer**, Aeronautical Research Engineer, National Aeronautics & Space Administration, Langley Aeronautical Laboratory*

TESTS show it is possible to reduce conventional fixed-orifice landing gear, or shock strut, loads by at least 50 per cent under single-pulse loading and 75 per cent under cyclic loading. The trick lies in

*National Aeronautics & Space Administration, Langley Aeronautical Laboratory, Langley Field, Va. This is a condensation of "Experimental Evaluation of Low-Bandpass Landing-Gear Shock Absorber for Pulse Loadings" (TN 4387).

varying the "sponginess" of the hydraulic cylinder damping.

Usually, the faster an aircraft taxis over rough land or water runways, the greater the load placed on the shock struts and the greater the load passed on to the airframe. In general, the force transmitted by a conventional landing gear shock strut increases roughly as the

square of the telescoping velocity; so over a fast, bumpy run or during an aircraft carrier landing the struts tend to become very rigid. Unless reduced, the severe shock loads that develop are transmitted to the supporting structure.

One way of taking up the shock is to design bigger struts. But this becomes expensive in terms of size and weight. A more effective method is to design a bandpass shock absorber that can be made sensitive to rate and duration or to the frequency of the pulse loading (depending on the application).

The control unit (*Fig. 1*) needed to "convert" conventional shock

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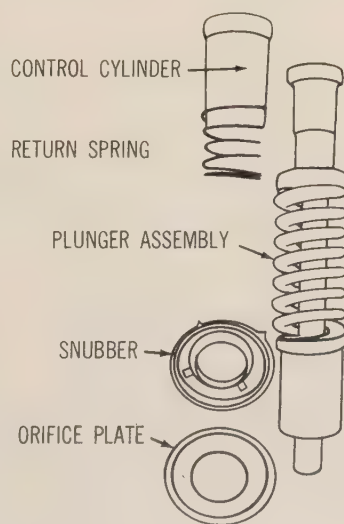
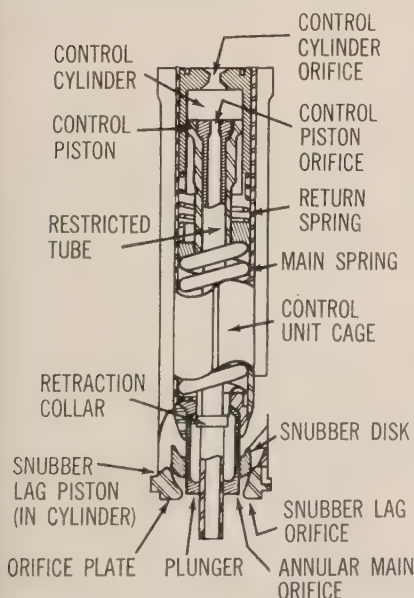


FIGURE 1: Low-bandpass control unit used for test evaluation weighs about 1½ lb. Detailed view of the control cylinder assembly is shown at right. Its three essential features, which distinguish it from the conventional shock strut, are a variable annular main orifice, a strut dump valve, and a frequency-discriminating lag valve.

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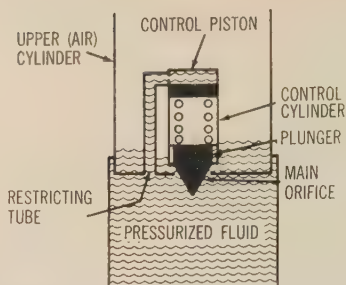


FIGURE 2: Rate-actuated low-band pass valve used in the shock strut tests. When the plunger is closed, the strut behaves as a conventional fixed-orifice design.

strut into a bandpass design in its three main functions provides the shock absorber with:

- a variable annular main orifice controlled by the rate of application and the duration of strut loading,
- a strut dump valve that quickly returns fluid from the upper to the lower cylinder for fast recycling under repeated-load conditions,
- a frequency-discriminating lag valve that snubs low frequency rebounds (such as occur in normal landings) but does not snub shock strut re-extensions for high frequency pulse loads.

An ordinary pressure-actuated relief valve is the most elementary type of variable-orifice control for instantaneous load relief. As the strut telescopes, the pressurized fluid in the lower hydraulic cylinder drives the plunger upward and opens the orifice wider to reduce the load.

The main drawback of this kind of valve is that it cannot distinguish between different loading rates and dumps the strut loading indiscriminately. Rate actuated relief valves do a better job, since the plunger position is controlled primarily by the rate of change of pressure in the lower cylinder, rather than directly by the magnitude of this pressure (Fig. 2). At low rates of loading, the strut behaves like a conventional fixed orifice strut.

Slow pressure increases in the lower cylinder force fluid up through the main orifice and restricting tube into the control cylinder. If the rate of change of pressure is small enough, the fluid can pass through the restriction with enough speed to force the control piston down against the spring and keep the plunger balanced in equilibrium.

With high frequency loads in-

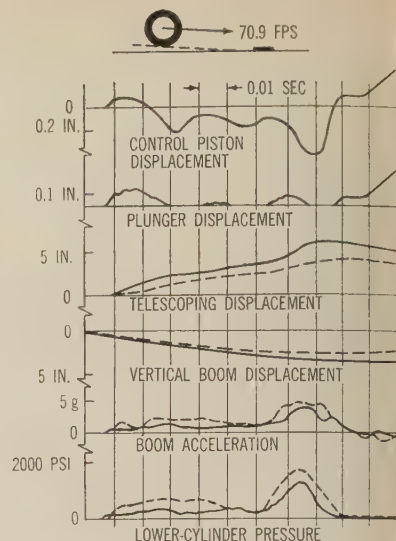


FIGURE 3: Time histories for low-band pass (solid) and fixed orifice (dashed) shock struts during impact on a step-shaped 2x12-in. bump at 225 psi tire pressure and one g wing lift.

volving high rates of change of pressure, the fluid flows through the restricting tube too slowly to move the control piston very far. The control piston remains essentially fixed, and the plunger is driven upward against the spring to open the orifice and reduce the load in much the same way as would an ordinary relief valve.

The second function of the control unit is taken care of by the dump valve system, which lets the strut recycle rapidly between loads. When the strut telescopes, the pressure in the lower main cylinder is *greater* than that in the upper cylinder, or air chamber—until the strut starts to re-extend. As soon as the pressure in the upper cylinder becomes greater, fluid is forced downward past the snubber disk (assumed to be in the "up" position) and continues down through the annular orifice formed by the plunger and main orifice plates.

Part of the flow is passed inward around the main spring through openings in the control unit cage. The pressure exerts a downward force on the plunger and an upward force on the control piston.

While the strut is telescoping closed, control cylinder pressure is adjusted by the orifices in the control piston and cylinder to a value somewhere between the pressures of the upper and lower main strut shock cylinders. During slowly ap-

more on page 96



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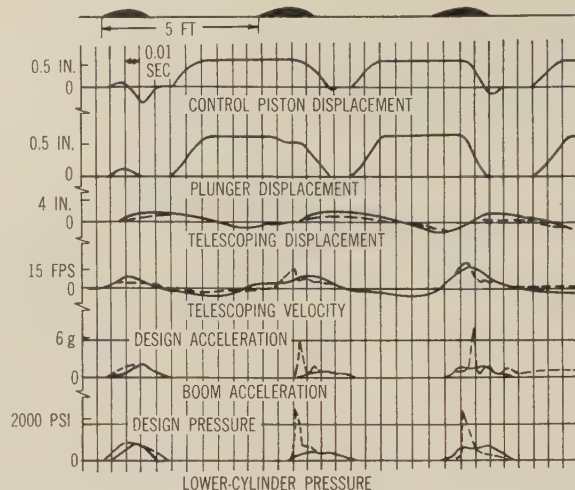
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FIGURE 4: Time histories for low-band pass (solid) and fixed orifice (dashed) shock struts for taxiing over 3 x 12-in. bumps at 0.63 g wing lift, 75 psi tire pressure, and 44 fps forward velocity.



plied pulse loads, the upward force on the plunger (resulting from the lower-cylinder pressure) is slightly over-balanced by the downward force on the control piston (resulting from the control-cylinder pressure communicated through the main spring).

During the re-extension stroke of the shock strut, when the lower main cylinder pressure is low, the high pressure in the upper cylinder exerts a net upward force on the plunged piston system, since the control piston area is considerably larger than the effective area of the

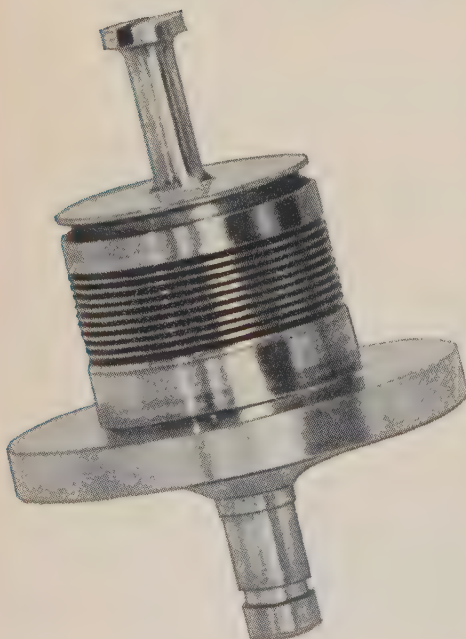
plunger. As the plunger is withdrawn from the main orifice during strut re-extension, fluid can flow rapidly downward from the upper to the lower main cylinder (assuming the snubber disk is in the "up" position) so ready the strut for the next compressive load pulse.

The third function of the control unit involves the operation of the frequency-discriminating snubber valve. Pressure increases in the lower main cylinder force the fluid to flow upward through the annular main orifice and drive the snubber away from its annular cylinder. Fluid enters and quickly fills the gap. When the strut begins to re-extend, the fluid in the upper cylinder that has been forced down through the main orifice drives the snubber disk back down into its closed position against the main orifice plate.

The disk carries with it the snubber lag piston, which is forced down into its cylinder. [Entrapped fluid escapes primarily through the snubber lag orifice(s) in the main ori-

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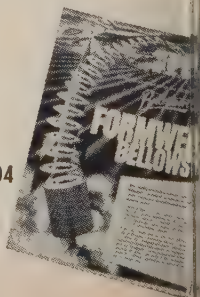
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fice plate.] There is a certain time constant connected with emptying the cylinder during which the strut is allowed to re-extend rapidly. Closing the snubber greatly reduces the fluid returning to the lower main cylinder so that the rebound of the strut is effectively snubbed for the remainder of the extension stroke.

With repeated high frequency impulses, usually involving small strut displacements of about an inch, the strut is unsnubbed on re-extension so that the strut stroke lost during each compression is largely regained during each re-extension. However, with low rate of application pulses—as during the landing impact or during taxiing over long, gently sloping bumps both conditions involving large strut displacements—most of the rebound stroke is effectively snubbed. As a result, the aircraft is not bounced off the runway by the potential energy stored in the air spring of the upper main cylinder.

Tests have been run to see just

how effective low-bandpass shock absorbers would operate. Taxiing runs were made over separated bumps to determine the strut pulse rate response (Fig. 6) and over closely spaced consecutive bumps to chart the strut recycling characteristics (Fig. 4). Finally, the effects of landing on single bumps were analyzed (Fig. 3).

The design of a "floating-piston"-type bandpass shock and vibration absorber has also been studied to extend the frequency range of application. Such absorbers could be used to eliminate the vibration of spring-suspended helicopter rotors or blades and for flutter damping.

One of the essential features of the low-pass floating-piston absorber is that the main piston is connected neither to the main piston rod nor to the main outer strut cylinder (Fig. 5). It merely floats in the fluid and lets the main piston rod slide through.

At low frequencies or rates of load application, the piston is auto-

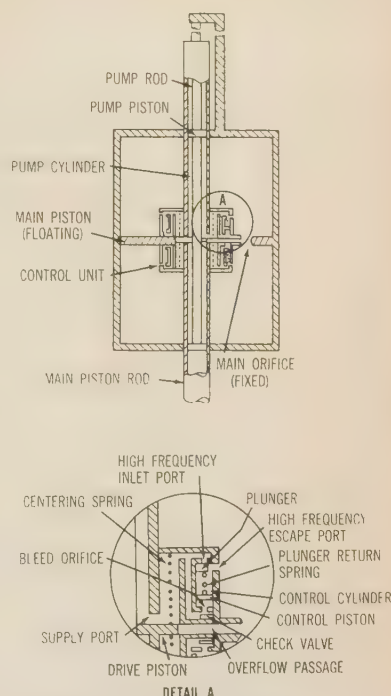


FIGURE 5: Floating-piston double-acting, low-band pass vibration absorber.

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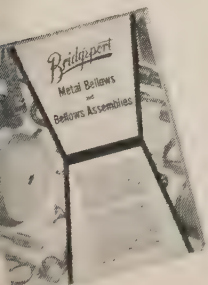
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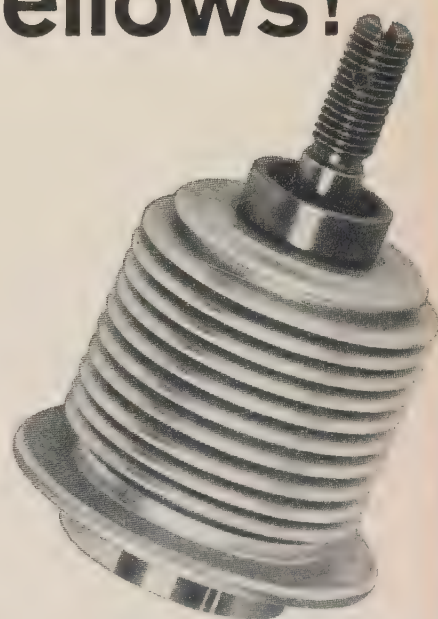
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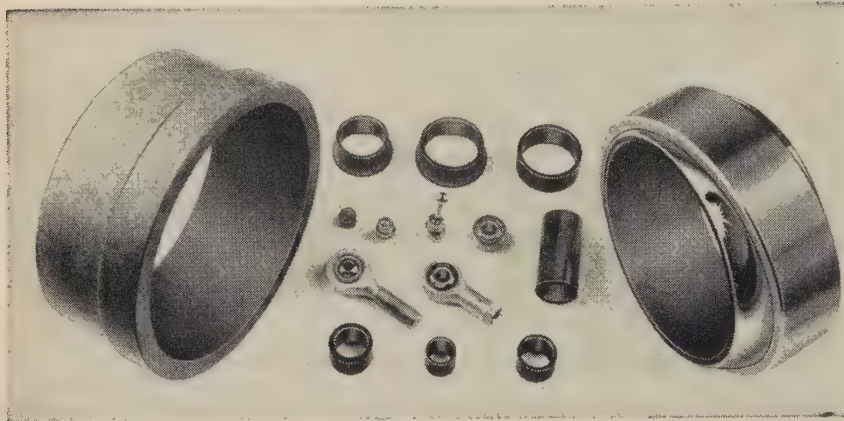
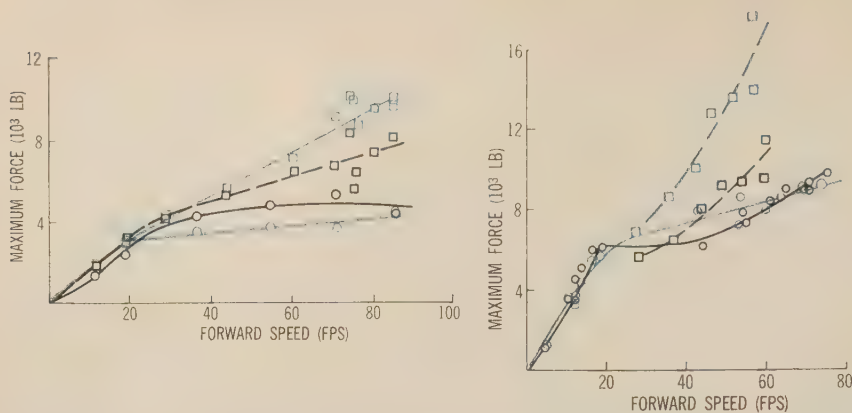


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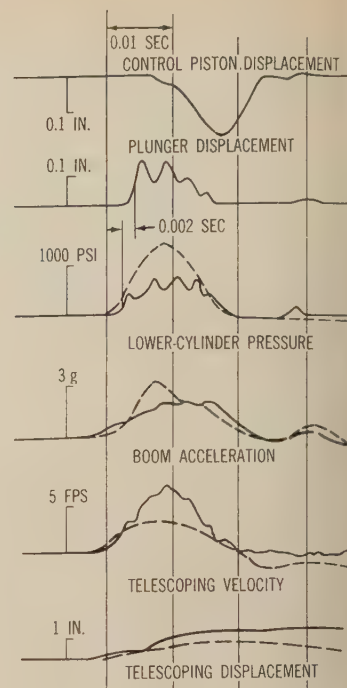


FIGURE 6: Maximum axial shock strut forces for a fixed-orifice design (dashed curve) and a low-band pass design (solid curve) during taxiing over a single, 10-in.-long bump at 0.88 g effective wing lift at 225 psi tire pressure for a two-in.-high bump (top left) and at 75 psi tire pressure for a four-in.-high bump (center). Plots from internal strut pressure are in color; plots from accelerometer data, in black. Right: Time histories for the same two devices for taxiing at 85 fps over a 2x10-in. bump at 225 psi tire pressure and 0.88 g wing lift.

matically coupled to the main piston rod by a fluid coupling and so simulates a conventional vibration absorber. At high frequencies, the piston is left uncoupled from the main piston rod, which slides freely up and down through the piston.

The automatic fluid coupling consists basically of a cylinder of fluid that becomes rigid and transmits load when contained, because of the fluid's inherent incompressibility. The coupling becomes "soft" when the fluid seeps away.

The floating-piston-type shock absorber apparently can be used over a much wider frequency range than the variable-orifice type. Analysis also indicates that the high frequency load reducing characteristics of the floating-piston absorber are superior to those of the variable-orifice design.—End

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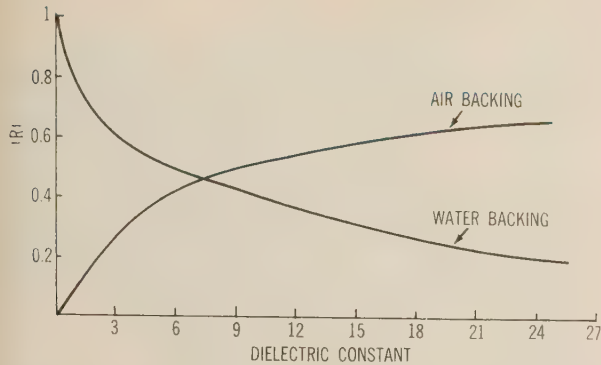
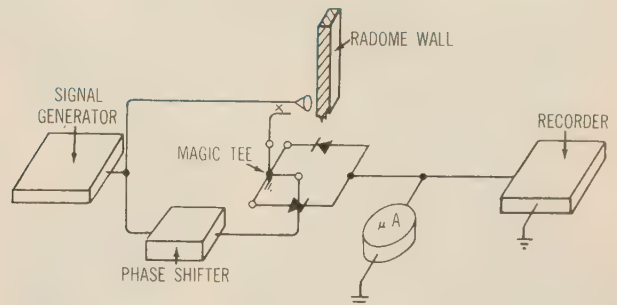


FIGURE 1: Reflection coefficient as a function of radome wall dielectric constant for air and water backing (left), assuming an interferometer frequency of 10^{10} mc. For



a constant over 7.35, air backing appears to be more desirable. Right: One-horn interferometer grind controller.

Microwave grinding

makes ceramic radomes easier to build

Fabricability has not been one of the strong points of ceramic radomes. This situation might change, however, with the application of the simplified production method described in this article.

by **Nestor Grechny, Jr.**, Applied Physics Staff,
Pilotless Aircraft Div., Boeing Airplane Co.*

CERAMIC radomes have received much attention as possible high temperature structures. Unfortunately, they are more difficult to fabricate than most other ceramic items.

For one thing, close-tolerance wall sizing is required. Normally, the ogival part of the radome is formed on a male mandrel, removed, and fired. Because of shrinkage and a small degree of deformation during firing, an inside and outside grind has been

needed to get the right wall thickness, which is the structure's critical dimension. The whole process is cumbersome, time-consuming and costly.

Now a method of sizing is available that is based on microwave control and requires grinding of only one surface. At first, the radome is formed with a slightly excessive thickness. After firing, it is inspected with a one-horn microwave interferometer, which reads the electric thickness of the part.

A grind is programed to remove the excess thickness from the outer

surface. A surface reference in the form of a transducer is located immediately adjacent to the grinding wheel. Since the grind is based on the removal of a known amount of material, it becomes independent of part size. The grind is monitored with the interferometer; if required, minor adjustment of the programed grind can be made.

After sizing, a final acceptance check is performed with the interferometer.

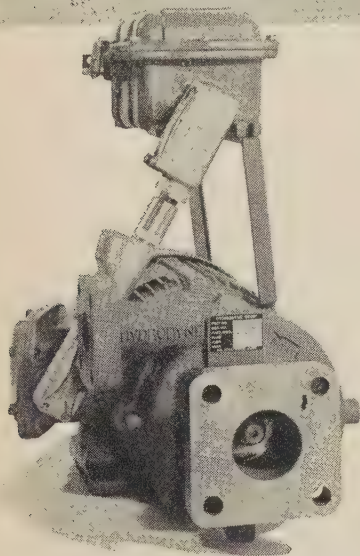
The one-horn interferometer is an extension of the normal two-horn-type and is more compact and versatile. It has already proved its controlling qualities in the sizing of plastic radomes.

As Figure 1 shows, energy from a stable microwave signal generator is split into reference and test arms of the interferometer. A single horn, located in the test arm, trans-

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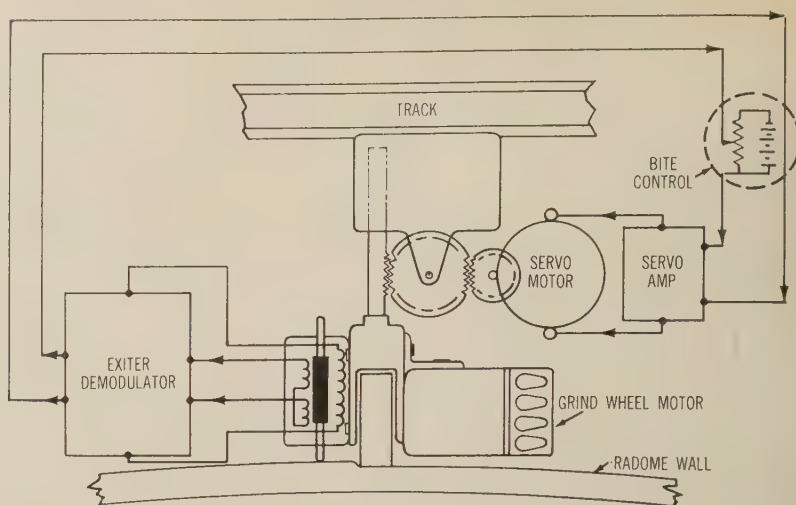


FIGURE 2: Surface reference grind instrumentation. Only requirements placed on the track are that it must not move the transducer beyond its operating range and must direct the grind wheel unit along the radome's longitudinal axis.

mits and receives a signal that is normally incident upon and then reflected by a dielectric panel (in this case, the radome wall).

The reflected energy is coupled into a magic tee and vectorially added in each side arm of the tee to the reference arm signal. In the tee, signals fed into the sum and difference arms under a matched-load condition, will result in equal outputs in the side arms when the two signals are in quadrature at the tee. The detection scheme, therefore, does not depend on amplitude and works in such a way that a null is obtained when the two signals are in quadrature. A simple dc bridging system is used; the output is both visually displayed and recorded.

Physical thickness isn't measured directly. Instead, the electric thickness is measured and then the physical thickness is calculated from the known material properties. The extreme uniformity of the dielectric constant of ceramics makes a constant relationship between physical and electric wall thickness a valid assumption.

Phase calculation requires many measurements

The measured quantity — the phase retardation of a plane wave normally incident upon and then reflected by the wall (backed with either dielectric material or an electric conductor)—is easily calcu-

lated. However, because of interaction between the electromagnetic horn and wall, the calculated phase value cannot be achieved without a long series of measurements. Regardless of the errors introduced in reading, a given phase condition is easily established and is repeatable. The repeatability feature makes it possible to find accurate wall thickness values.

The phasing error problem, which is the direct result of horn aperture re-radiation, is resolved by using the instrument as a comparator rather than an absolute gage. The interferometer in effect is a referencing system capable of measuring small variations in wall thickness that are centered about a target value.

Set of primary standards is necessary

To establish the interferometer as a reference system, a set of primary standards is needed. Each standard is fabricated from an appropriate sample of the dielectric material to be used, and its thickness measured with a micrometer. Each sample must be uniform, have parallel faces, and be backed with the same material that will back the radome wall. Phase is then measured by placing the sample normal to the axis of propagation and at a fixed distance from the horn.

more on page 106



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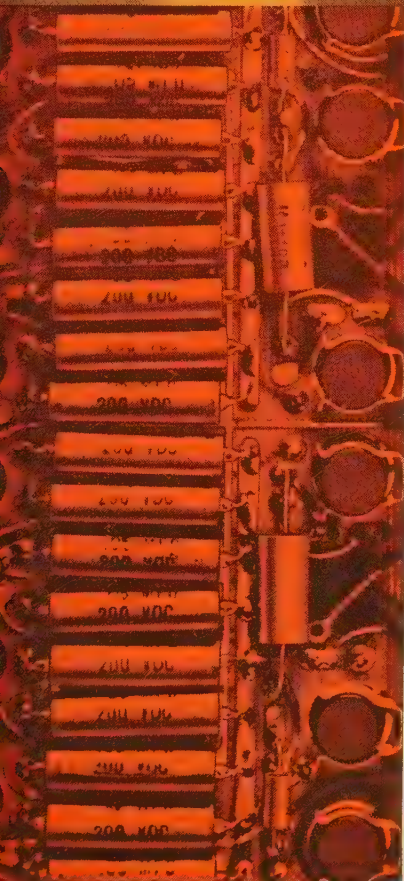
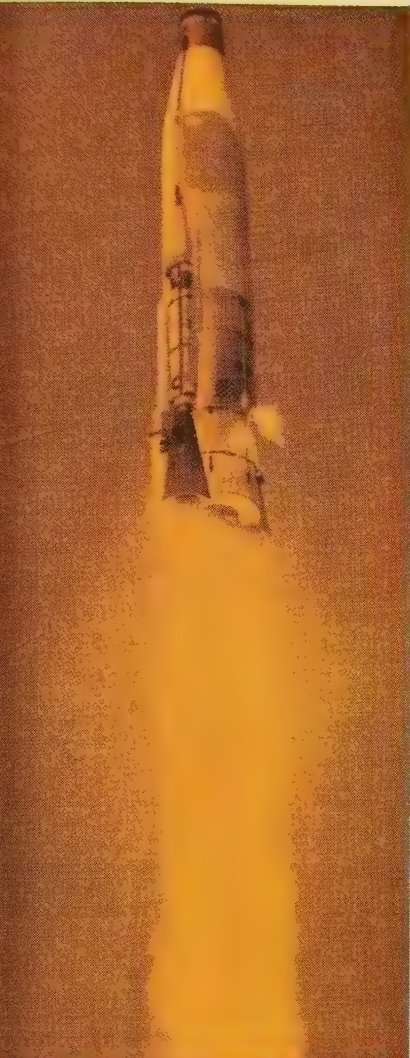
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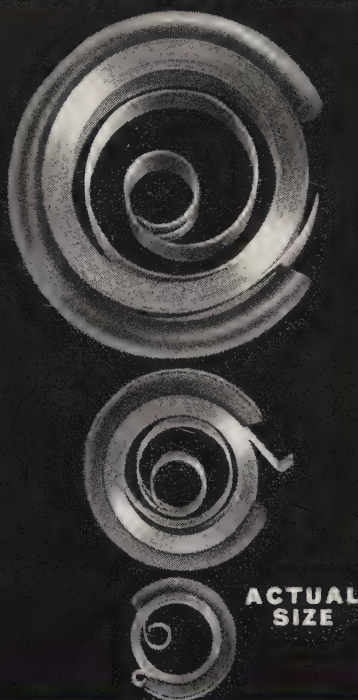
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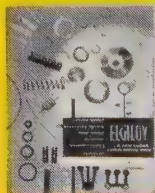


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The electric phase read on a phase shifter is thus associated with the sample's known physical thickness. From several samples, a relationship is established between physical thickness and phase readings. The sample dielectric constant should not deviate from that of the wall material by more than a few per cent.

The detection system is calibrated to read physical thickness directly. This is done by series-bucking the output from each detector in the tee through a center-reading galvanometer. A parallel output is provided for recording purposes. Through adjustment of the phase shifter, signals in the reference and test arms of the interferometer are set in quadrature at the target phase value found from the standards. Thus the galvanometer is nulled at the center thickness.

Horn-to-wall spacing must be constant

Figure 3 shows the relationship between physical thickness and interferometer phase as established by the standards. By introducing the correct phase variations with the phase shifter and with proper shunting of the galvanometer, the latter's scale is calibrated to read directly a limited range of physical thickness variations about the target value (Fig. 4).

It is vital that the spacing between horn and wall be held constant. Problems may arise in maintaining normalcy and constant spacing for some radome designs. In general, the proper solution is to use a rigidly mounted, rotating microwave joint immediately preceding the horn. Wide-set outriggers riding the radome surface are tied to the horn and space it from the radome. A desirable spacing is 0.002 in.

Interferometer outriggers ride radome surface

The interferometer is mounted so that the outriggers ride the radome surface under the force of gravity. The tracking drive is set in the plane of the longitudinal axis of the radome with the long dimension of the horn parallel to the radome axis, thus minimizing curvature errors.

Part curvature introduces errors in interferometer readings for small

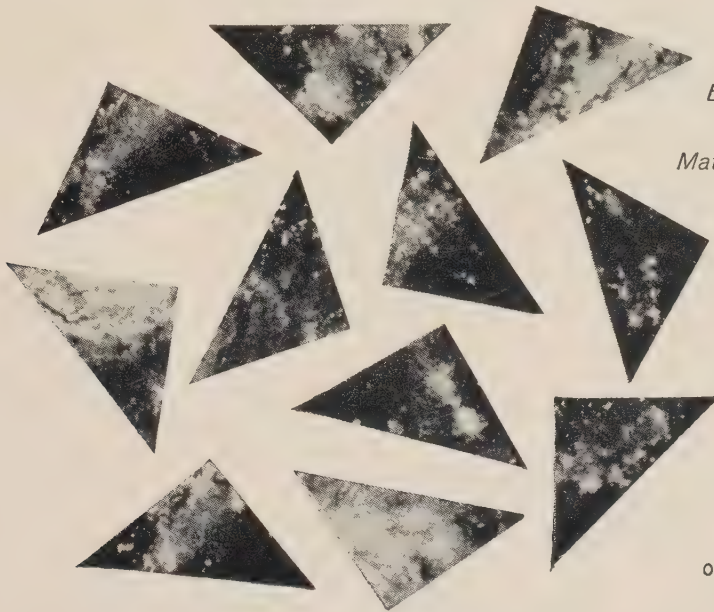
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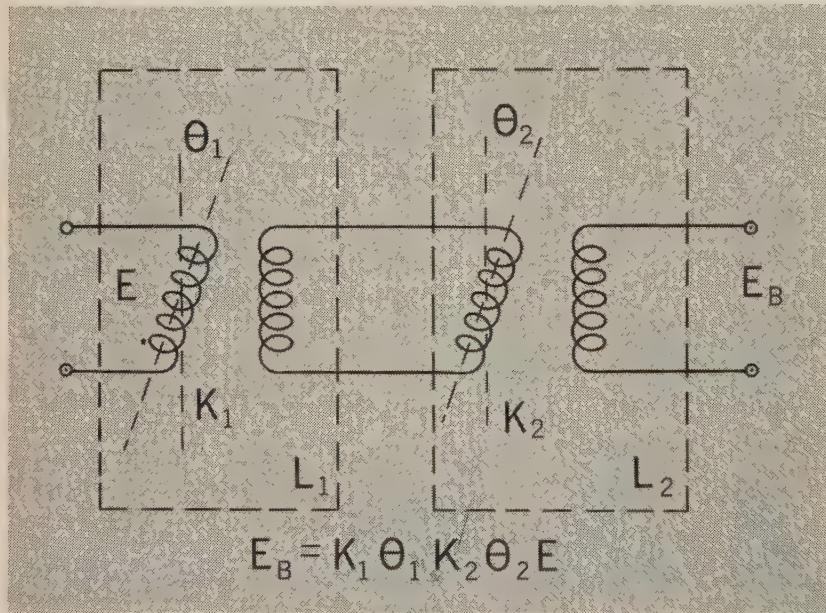
ENGINEERING REPORT ON BENDIX COMPONENTS

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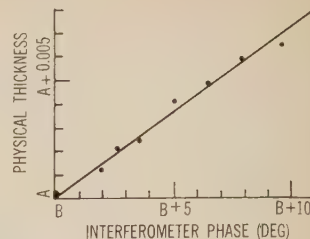


FIGURE 3: Relationship between one-horn interferometer's phase and the physical thickness of standards.

radii. To find these errors, parts of various radii of curvature must be measured with both the interferometer and a micrometer. Deviations in readings are then used as a correction for the interferometer readings (Fig. 5).

An electric conductor is a good backing

The best accuracy and thickness sensitivity is achieved when the maximum interface reflection is obtained from the panel interface farthest from the horn. The magnitude of reflection at the interface between media a and b is given by:

$$|R| = (n_b - n_a) / (n_b + n_a)$$

where n is the refractive index. In general, the medium on either side of the radome wall will be air. However, if it's desirable to increase sensitivity, the radome may be inverted and filled with water (Fig. 1).

An even more desirable backing is an electric conductor that results in total reflection at the interface. It can be obtained by spraying the radome interior with a metallized paint or pigment that later on can be removed with a solvent.

Water backing may give better readings

Although Figure 1 shows that air as a backing gives better reflection than water at higher dielectric constants, water may give more accurate readings. Inaccuracies result from the energy transmitted through the radome wall, reflected by the far wall back through the wall nearest the horn, and received by the horn. An electric conductor as backing eliminates this reflection. With air as the backing, the radome interior must be lined with

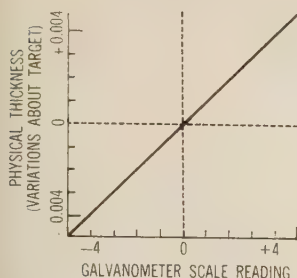


FIGURE 4: Calibrated physical thickness as a function of galvanometer readings. Phase variations are easily detected by the interferometer. The minimum detectable variation is on the order of 0.2 deg.

microwave-absorbing material to attenuate the undesirable reflection. Water, however, is highly attenuating at microwave frequencies.

After firing, the radome is inspected with the interferometer and the thickness is mapped over the entire radome area. The surface of the radome is the only reference needed for the thickness measurements and later for the grinding operation.

Figure 2 shows the electric circuitry for maintaining the surface reference. Track tolerances are very loose and are a function of the transducer's range of linear operation. If, for example, the linear range is $\frac{1}{2}$ in., tolerances of about ± 0.2 in. are acceptable.

Transducer output gives grind depth

The output from the surface reference transducer drives the servo motor, which then drives the grind wheel in the depth dimension. The wheel is stopped at the correct depth when the transducer output reaches a null condition. Grind depth is determined by the bite control, which merely introduces a voltage on the transducer output.

As we have noted, the manually controlled grind can be monitored with the interferometer and minor program corrections can be made. Normalcy and constant spacing between horn and part must be maintained, although 1-2-deg and 0.001-0.002-in. spacing errors are often permissible.

For complete automation, the interferometer output can be used as the grinding wheel bite bias. A

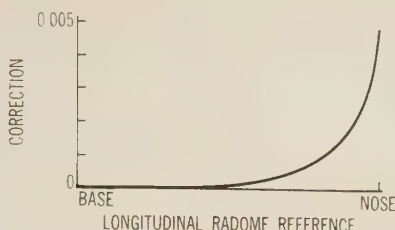


FIGURE 5: Thickness correction as a function of radius of curvature for a particular wall material.

data storage unit must be added to account for the time delay between reading and grinding at a point. The time delay can, for instance, be introduced with a tape of constant time lag if the part is ground in a spiral at constant angular velocity. However, a preliminary inspection of the part would still be advisable.

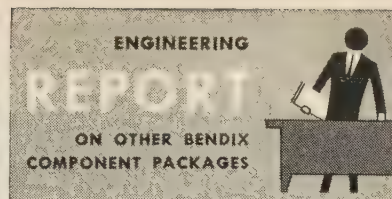
IPD can be used as the main parameter

The fundamental qualities of a radome are expressed by the radome boresight errors or boresight error rates, transmission, and reflections by the radome into the seeker. These qualities are minimized, maximized, or optimized by the radome designer as he chooses the radome wall dimension.

More recent design methods assume the radome "insertion phase difference" (IPD) as the basic design parameter. The use of the IPD does not in any way invalidate the sizing method we have described. Since the IPD is the phasing difference presented by the radome wall to an impinging electro-magnetic wave, standards can be set up to relate the one-horn interferometer's phasing with the IPD or the standard. The IPD is found by standard two-horn interferometry methods, using parallel polarization and measuring at Brewster's angle.—End

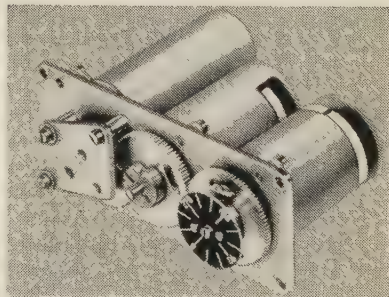
A Correction

A fairly disastrous typographical error crept into the first line of the article "Designing with AM-350 and AM-355 High Strength Stainless" in the February 1960 issue (page 79). These steels of course are not "semi-automatic," as was mistakenly stated, but *semi-austenitic*. Further on in the same bedeviled article, at the end of the third paragraph on page 89, a wrong R_o value is given—it should be 40 R_o , not 49.



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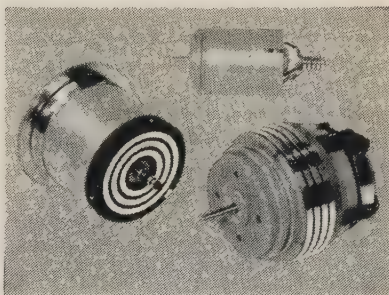
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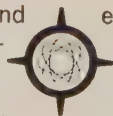


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SPECIAL REPORT: electronic countermeasures

page 120

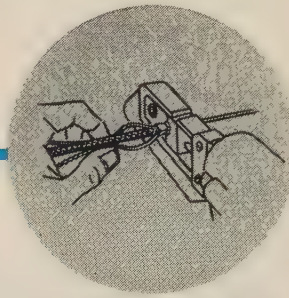
WHEN IT COMES TO SHIELDED WIRE



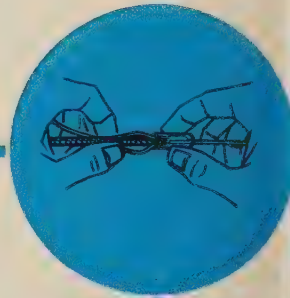
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SLIP
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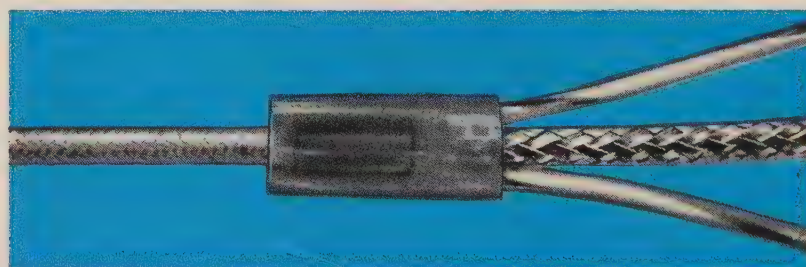
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aerospace electronics intelligence

Sarnoff foresees boom times for electronics

BOOMING electronics industry is forecast for the next five years by Gen. David Sarnoff, RCA board chairman. By '65, the general expects electronics to be doing a \$25 billion yearly business.

Sarnoff sees three big "C"s in electronics' near future: computers, controls and communications. The total now being spent in these three fields is \$2 billion a year. Sarnoff sees it sprouting to some \$7 billion by '65.

SARNOFF also predicted that the electronic percentage of the defense budget—which is now around 16 per cent—will rise to 20 per cent in five years. Its volume then will be about \$10 billion, he said.

Sarnoff served warning on Burroughs, IBM, Remington Rand, and other leaders in the computer field to make room for RCA. He said RCA is putting heavy emphasis on its data processing operations. It already has 60 orders for its 501 data processing system, he claimed. Fifteen of these systems already have been delivered. Sarnoff also pointed out that 98 per cent of the 501's parts are actually made by RCA.

GROUND ECM RECEIVER contract was awarded to Sylvania by Rome (N. Y.) Air Development Center. The \$7 million development and production job will be handled by Sylvania's Mountain View, Calif., and Waltham, Mass., labs.

Bell makes high claims for its long range inertial guidance system

"MOST SUCCESSFUL and reliable inertial system yet tested" is the claim of Bell Aircraft engineers for their secret, high performance guidance package for long range guided missiles and space vehicles. The system, which has been through extensive flight trials, features unique gyro and accelerometer design, that Bell believes, will raise the state of the inertial art a few notches. It is because of these designs, the company states, that, "for the first time, the application of ultra-precise inertial techniques has become practical under field conditions."

The accelerometer forms the heart of a digital velocity meter that uses a novel technique to obtain an extremely linear relationship between acceleration and frequency.

PLASMA OSCILLATOR designed by Sperry Gyroscope researchers oscillates at frequencies between 700 and 2000 mc. The plasma is formed by sending a narrow beam of electrons through rarefied hydrogen gas contained in an electromagnetic envelope. The electron beam strikes the hydrogen atoms with enough force to tear them apart, creating a plasma of charged hydrogen particles and electrons.

Dr. James E. Hopson, the Sperry physicist who performed the plasma experiments, told SPACE/AERONAUTICS that conceivably the electric circuits formed by the plasma may eventually replace, or enhance the operation of, electronic devices that now use wires, capacitors, and other conventional elements.

High upper frequency limits given for plasma

UNDER certain conditions, Hopson says, the plasma behaves as an ordinary electric circuit that interacts with the electron beam and generates microwave energy. The plasma circuit, he explains, couples into the electron beam, which acts like an antenna to convey the microwave energy out of the plasma, so that it can be put to work.

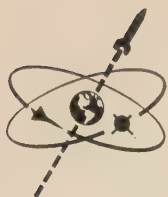
Hopson points out that the upper frequency of a generated plasma is limited only by the magnetic field strength and the interacting electronic structures. With current equipment, frequencies up to 280 kmc could be generated, Hopson claims.

EXPERTS interviewed by SPACE/AERONAUTICS regard Hopson's experiment as one of the most significant in the plasma electronics field. They believe that, if enough power can be handled in this manner, radical changes are in store for microwave design.

Sperry has not disclosed the power that can be generated by its plasma oscillator or the power that can be handled by the plasma circuits.

NEW TYPE of airborne radar data transfer system was developed and delivered by Motorola under \$1.5 million Signal Corps contract. The system, claims Motorola, is the armed forces' first tactical air-to-ground sensor. Its main purpose is to relay airborne radar-derived terrain maps to ground forces. An encoder and a transmitter in an airplane get their information from a companion airborne radar and transmit it to

more on next page



aerospace electronics intelligence

a receiver, decoder, and indicator on the ground.

The maps, says Motorola, can be displayed on a ground viewer within seconds after the airplane passes overhead. By a new photographic technique, a permanent map can be produced immediately on film.

MYSTERIOUS ANGELS (radar returns from unidentified objects) are causing a lot of head-scratching at Marconi's research labs in Great Baddow, Essex, England. These particular angels are unique, the researchers report, in that they start out (like ordinary angels) as spots of light but then spread out in the form of rings. Each ring is followed by many others—like ripples in a pond after a pebble is dropped. Observations over a few months show that the angel rings occur only from half an hour before to half an hour after sunrise.

Two theories have been advanced by Marconi's to explain these angels: (1) they are caused by flocks of starlings; (2) they are caused by thermal redistribution of the atmosphere at sunrise. Neither theory is fully satisfactory. Marconi's would like to know if any other radar observers have noticed these angels or similar phenomena.

GE's future prices for tunnel diodes depend on volume and process control

TUNNEL DIODE production has started at GE's Semiconductor Products Dept., Liverpool, N. Y. Simultaneously, GE chopped prices on the new components from \$60-75 per engineering sample to \$10. Future prices, GE says, will be set by the volume of manufacturing and the degree of process control that can be achieved on the production lines.

AUTOMATIC transistor production line at IBM's Poughkeepsie, N. Y., facility is turning out NPN alloy junction transistors at a rate of 1800 a day. An automatic assembler designed by IBM engineers will hold tolerances as close as 0.0005 in., according to the company.

The machine takes up 500 sq ft of floor space and has nine main units connected by conveyor belts: six turntables, two ovens (for alloying and bonding), and a welder. Preformed parts—emitter and collector dots, germanium disk, base tab, whisker wires, and mounting base — are automatically fed to the turntables. Each table automatically injects one type of component — by

vacuum or gravity feed — into small carbon cylinders, or "boats". The boats, together with fitting plugs, position and transport the parts on the conveyor belts between assembly stations.

THE SYSTEM is self-checking, says IBM. Photo-cell and mechanical devices at each turntable signal memory circuits to reject boats with missing or poorly positioned parts. Before welding, each unit also is electrically checked for bonding.

Its assembler can be modified to assemble any type of alloyed transistor, says IBM.

LOW ALTITUDE RADAR altimeter contract of \$600,000 was given to Sylvania by BuWeps. for its ANP-117. A low altitude version of the widely used APN-22, the -117 will be carried mainly by sub-hunting copters.

Like the APN-22, the -117 it is an FM-CW type. It has a 0-1000-ft range and an accuracy of ± 2 ft or five per cent. Cost per unit is reported to be \$4000.

ECI gets big contract, plans to merge with Maxson

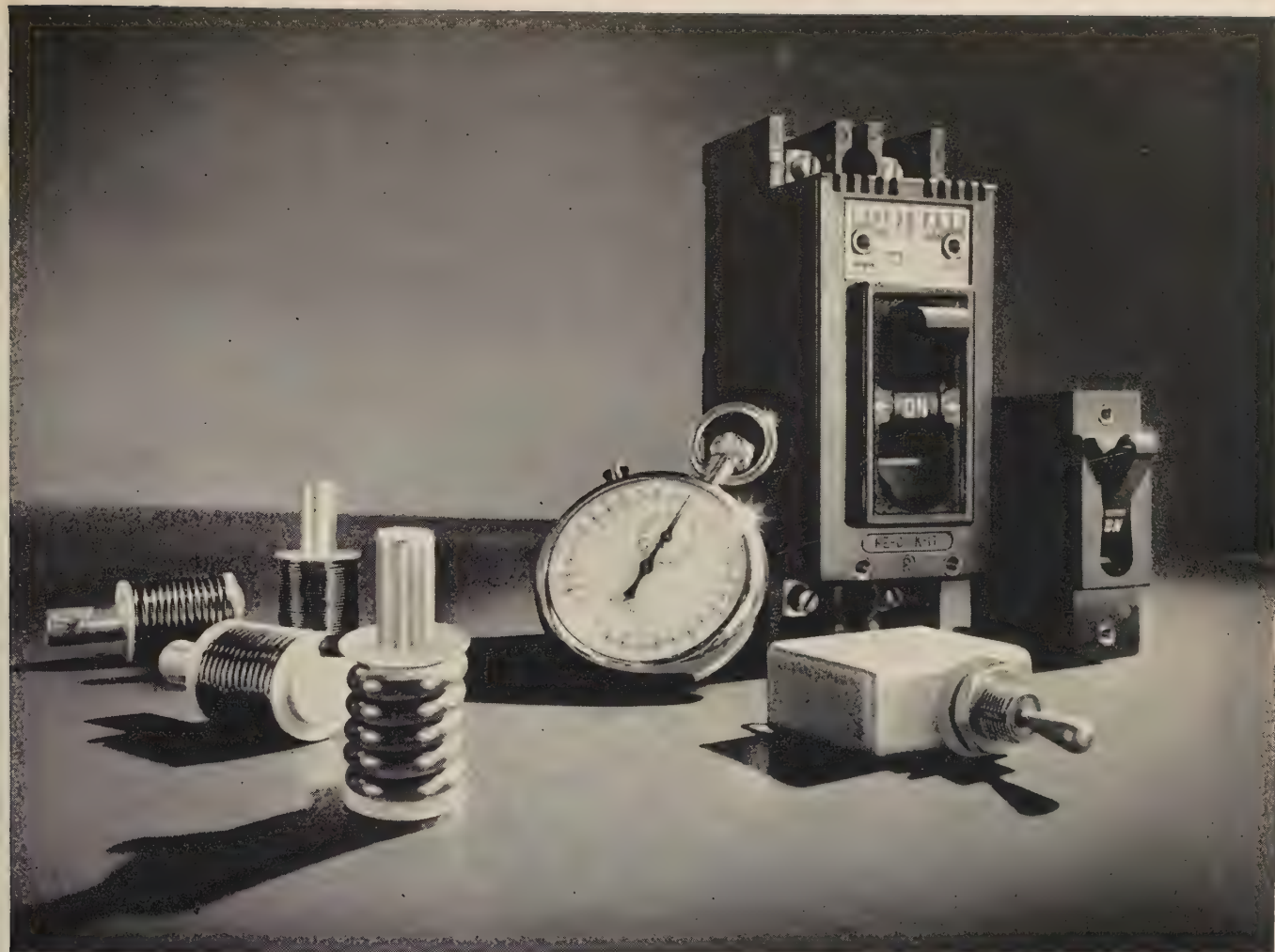
PROPOSED MERGER of Electronic Communications, Inc., and Maxson caught most of the aerospace electronics industry by surprise. The new firm would be able to take on larger contracts and have a better chance in competition with many of the larger electronic firms.

The merger basis is one share of ECI for 1 $\frac{3}{4}$ shares of Maxson. The merger deal still has to be approved by the stockholders of both firms.

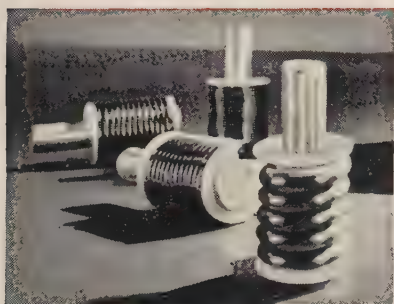
THE MERGER AGREEMENT came just after ECI had garnered one of the largest contracts in its history: a \$9.5 million order from Burroughs for development and production of a large chunk of the "airborne long range intercept" program. ECI will furnish a one-kilowatt UHF amplifier for radar surveillance aircraft. Radar data will be encoded and sent back to Sage ground centers via this amplifier.

MISSILE GUIDANCE and tracking radar and fire control equipment developed and built by Sperry Gyroscope will be installed on USS Long Beach, the Navy's first nuclear-powered cruiser. The radars will be four SPG-55s for guiding the beam-riding Terrier, two SPG-49s for tracking targets for the Talos, and two SPW-2s for guiding the Talos (after their guidance beams have been

more on page 116



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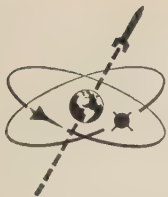
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aerospace electronics intelligence

positioned by SPW-2s). Two Sperry Mk 11 computers (one for each Talos system) and a "weapon direction" system for both missile guidance radars will also be installed.

TACAN radio beacon simulator test set that can ground-check the Tacan navigation systems in 25 aircraft at one time is being built by Stromberg-Carlson, San Diego, Calif. The set was developed for Hughes Aircraft as an integral part of Mart (Mobile Automatic Radiation Tester).

S-C's test set can operate on any two of the 126 Tacan channels. (One channel has to be in the lower frequency band and the other in the higher, however.) It simulates ranges up to 180 miles in 20-mile increments with one per cent accuracy. It can also select one of two preset azimuths from any of 18 bearings with a $\frac{1}{4}$ deg accuracy. Both a high power output for radiation testing and a low power output for direct bench testing are provided.

Two underwater systems for locating the impact points of ballistic missiles

UNDERWATER DETECTION systems developed by Bell Labs for the Navy are used to locate the impact points of ballistic missiles and re-entry vehicles on both the Atlantic and Pacific Missile Ranges.

According to Bell, several systems have already been set up on islands along the ranges. One is on Ascension Island in the Atlantic.

Two types of systems have been built by Bell: (1) a surface impact detecting system that detects and pinpoints the sound of the missile as it hits the ocean surface and (2) a system using a Sofar bomb technique. In the first system, six hydrophones are installed on the ocean floor and connected by cable to a shore station. Five are located at the apexes of a pentagon, the sixth is in the pentagon's center. Data from at least three of the phones is needed for an acoustic fix.

IN THE SOFAR METHOD, a bomb is ejected from the missile just before impact. A pressure mechanism explodes the bomb in the deep sound channel (about 600 fathoms below the ocean surface, where the temperature characteristics of the water form a low-attenuation duct for acoustic waves). Sounds in this channel can sometimes be heard thousands of miles away by hydrophones lowered into the channel.

To detect the Sofar bomb explosion, Bell moni-

tors the channel over a large area with pairs of hydrophones connected to shore stations via cable. The time difference in the arrival of the explosion sounds at two phones provides the acoustic fix.

TITAN'S terminal guidance will be studied by Space Electronics under a \$96,000 contract with Avco's Research & Advanced Development Div. The work is part of Avco's \$73 million USAF contract for designing an advanced re-entry vehicle for the Titan.

GE fire control in highly electronified F-105D

"THUNDERSTICK" fire control system, developed by GE's Light Military Electronics Dept. is the brain behind the potent punch of Republic's F-105D all-weather fighter bomber. It controls a Gatling cannon, missile delivery (Sidewinders reportedly will be carried by the F-105D), and bomb delivery. Tied into GE's A42GS-S automatic flight control, the Thunderstick can loft a nuclear bomb at a ground target while reversing direction in an automatic Immelmann. An Autonetics monopulse map, search, and tracking radar supplies the major information inputs to Thunderstick.

F-105D IS the most electronified fighter bomber ever built. Since it may be the last of our fighter bombers, this distinction may remain unchallenged. According to a rough estimate, about one third the cost of the F-105D goes for electronics.

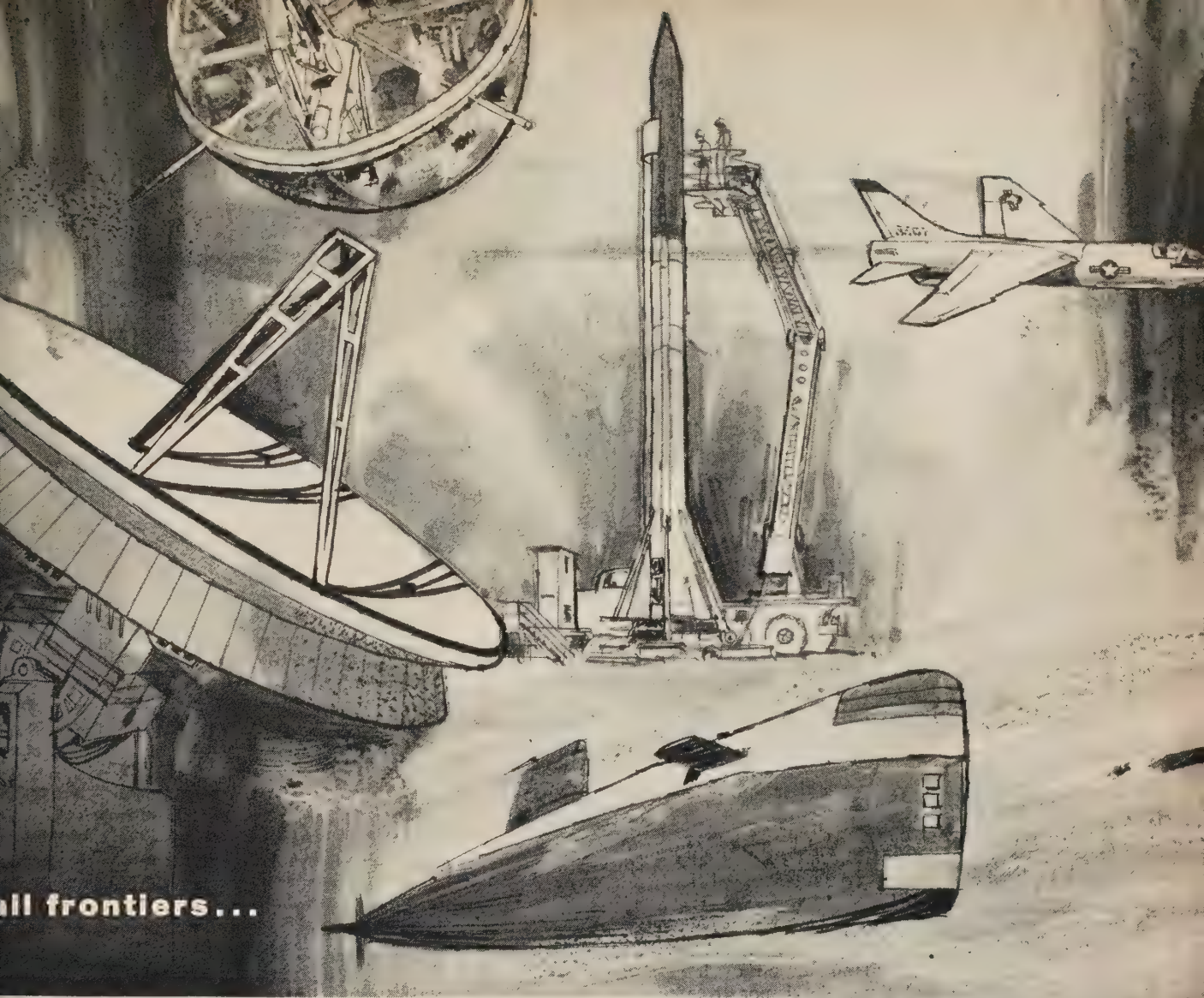
Major items besides the fire and flight control systems and the monopulse radar are communications, identification, and navigation equipment, Doppler radar, an integrated instrument system, and the APS-54 radar warning receiver.

TV PICTURES of maps, charts, and photos were sent over 500 miles of telephone lines in a recent demonstration at Rome Air Development Center. Built by IIT Labs, Ft. Wayne, Ind., for RADC, the system has a scan rate of 10-120 seconds per frame, depending on the required image clarity. Average time per frame for ordinary use is 40 seconds.

Before transmission on over the wire lines, the bandwidth of the signal is reduced (on the order of 1000:1) by scan-conversion storage tubes. The narrow-band signal is reconverted to wide-band at the receiving end.

more on page 118

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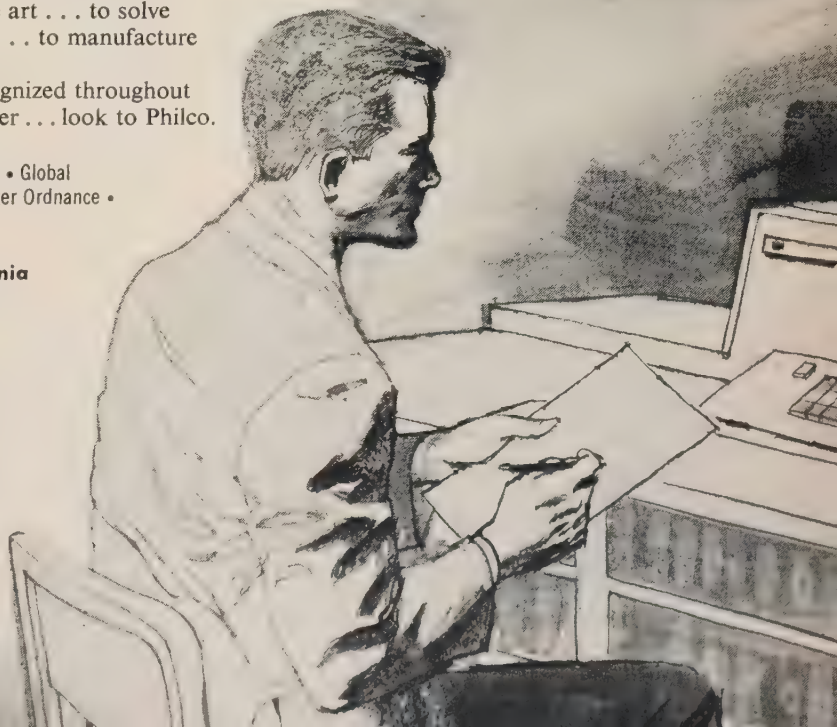
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Digital simulation of planes with new trainer

UNIVERSAL OPERATIONAL flight trainer developed by Sylvania for U.S. Naval Training Devices Center, Port Washington, N.Y., under a \$2 million contract was formally accepted by the Navy. The trainer, says Sylvania, represents the first use of a general-purpose digital computer for full-scale, real-time flight simulation. The digital computer makes it possible to simulate a variety of aircraft types, while the special-purpose analog computers used in more conventional flight simulators are restricted to a single airplane type, claims the company.

The Navy center plans to use the trainer to study the digital simulation of high speed aircraft in real time. To demonstrate the trainer's versatility, Sylvania made successive simulated flights of the supersonic F-100A and subsonic F9F-2 jet fighters.

AIR-SUPPORTED antenna towers, designed by American Electronic Labs, Philadelphia, Pa. can be inflated in minutes. They support external antenna wires or have the wires attached or coated to their inside surface. One type built by AEL is of Fortizan rayon impregnated with neoprene. It is raised by inflating with air at a few psi.

According to AEL this antenna can stand winds up to 87 mph. When deflated, the antenna stores in a transit case.

Amplifier shrunk 83 per cent in size through vapor cooling

VAPOR COOLING allowed Hughes Aircraft to shrink the size of a one-kilowatt airborne linear power amplifier by 83 per cent. The amplifier, part of the HF communications system of Convair's B-58, was reduced to an 8½-in. cube by completely immersing it in a fluorochemical coolant that dissipates about 1600 W of heat. The heat vaporizes the liquid, which rises to the top of the coolant enclosure, which in turn is cooled by ram air.

This cooling technique, according to Minnesota Mining & Manufacturing, which makes the fluorochemical, is about 100 times more efficient than simple air convection for transferring heat generated by hot spots.

RADIOISOTOPE ALTIMETER developed by Boeing for high altitude aircraft and missiles works by measuring the radioactive back scatter, which is proportional to atmospheric density.

Intended for use only above 25,000 ft, the new altimeter provides more accurate high altitude readings than do conventional pressure types. Wind tunnel and lab tests at Boeing show the unit should give dial altitude readings accurate to within an estimated 500 ft or less above 25,000 ft.

Boeing studies altimeter for use as Mach indicator

THE RADIOACTIVE source is a beta-emitting isotope with a long half-life. Atmospheric back scatter from this source is picked up on a stilbene-impregnated plastic scintillator and then sensed by a photomultiplier tube.

The accuracy of its altimeter, says Boeing, depends much more on vehicle speed, altitude, and configuration than does that of conventional pressure altimeters. Boeing is also studying the use of the density altimeter as a Mach indicator. In this application, the unit would measure the air density at the flying speed and the stagnant air density and then compare the two.

ZENITH'S PARAMETRIC amplifier and a technique the company calls "synchronous pumping" combined to give an L-band ground radar a sensitivity improvement equivalent to a 50 per cent increase in range or a 125 per cent increase in area coverage. According to Zenith, these results were gotten in tests at Rome Air Development Center.

"Synchronous pumping" is a "sophisticated" method of operating a parametric amplifier with a radar. The amplifier is energized by RF power of precisely twice the frequency of the transmitted radar signal. According to Zenith, its technique avoids the performance loss due to the idler channel.

Zenith's parametric amplifier is a vacuum-tube type developed by the company last year. It is regarded in the industry as one of the more promising low-noise microwave amplifiers.

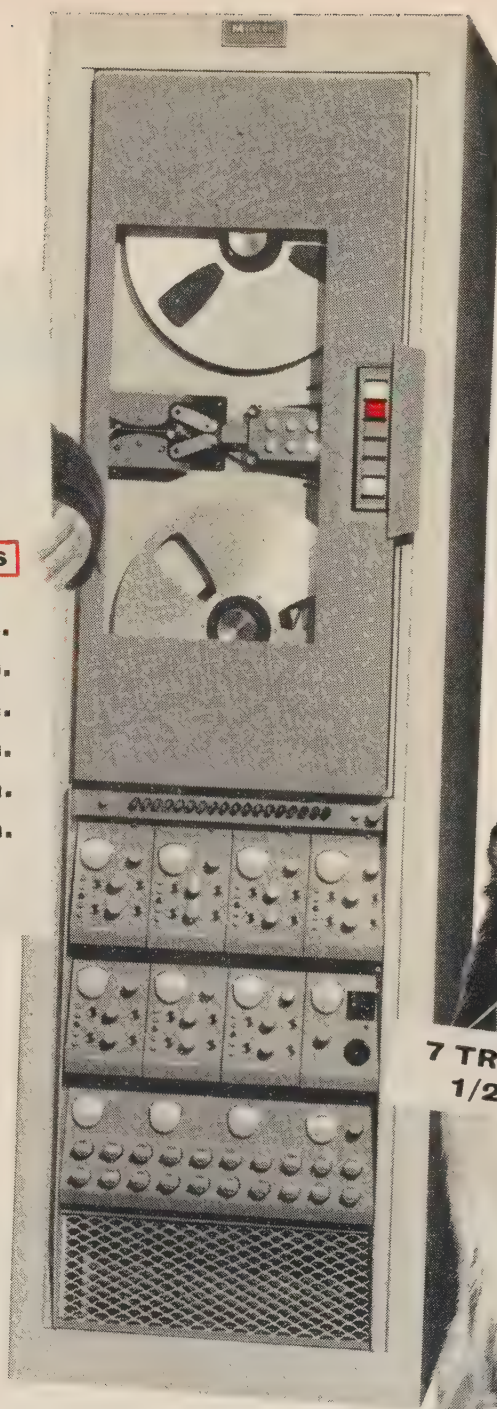


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1

Electronic warfare offers fluctuating market

- Worth \$500 million a year in R&D and production
- ECM contractors hard hit by ALQ-27 cancellation
- Anti-radar missile would boost ECM business

by **Bernard Kovit**, Associate Electronics Editor

ELECTRONIC countermeasures is really an integral part of a bigger field—electronic warfare. The three main areas within this field are:

- *Electronic Reconnaissance (ER)*—the detection and location of the enemy's sources of electromagnetic radiation and the analysis of the physical and electronic characteristics of his communications, radio navigation, radar, and electronic countermeasures equipment;
- *Electronic countermeasures (ECM)*—any means used to deny to the enemy the use of his electronic communications, nav aids, weapon guidance and control, fuzing and arming, surveillance and tracking radars, etc., (generally by adding to the normal signal or producing artificial changes in the enemy's sensed or transmitted data);
- *Electronic counter-countermeasures (ECCM)* —



SOVIET radio jamming towers (above) reportedly were caught in this shot by an American tourist outside Moscow. On our side, a nationwide network of powerful, agile FD radars like the Sperry AN/FPS-35 (right) will let us pick up airborne targets despite heavy countermeasuring.

techniques for avoiding, disrupting, or cancelling enemy ECM.

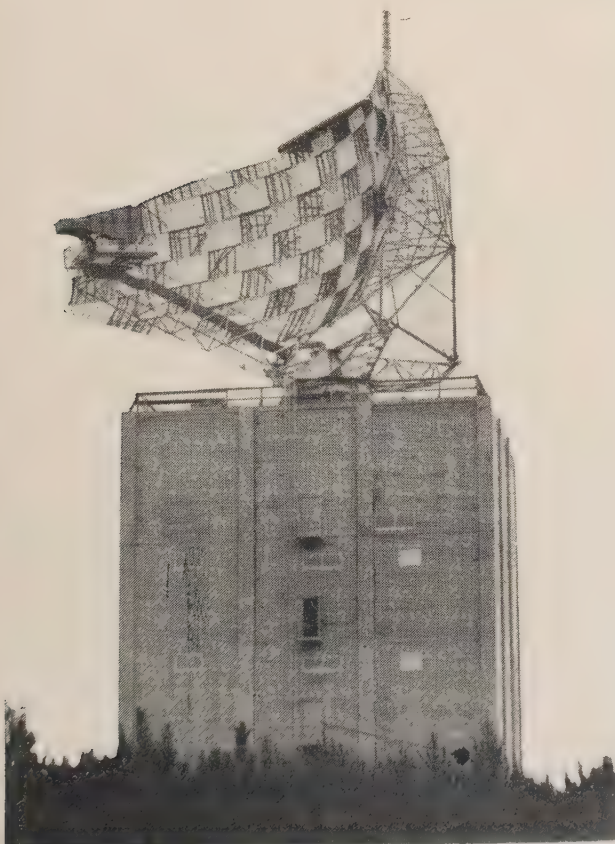
Electronics editors Jim Holahan and Bern Kovit did end of World War II, when most of the basic ECM and ECCM techniques were developed. Its second peak didn't come until a long time later—some five or six years ago, when USAF reportedly awoke to the realization that vehicles and warfare itself were becoming more electronified, and threw itself and industry into an ECM extensive program. The renewed emphasis on ECM reached an all-time high with the placement of orders for R&D and production for completely integrated ECM systems for the B-52H and the B-70 bombers. Had Sperry been allowed to continue its work on the AN/ALQ-27 system for the former and Westinghouse its work on the second-generation ECM package for the latter, we probably would have seen the annual ECM market approach the billion-dollar mark in fiscal 1961.

At present, a SPACE/AERONAUTICS market survey shows, the electronic warfare field is worth upwards of \$500 million a year in R&D and production money. Airborne recon accounts for roughly 30 per cent of this total, active airborne ECM for 50 per cent, and all ground radar and other ECM for 20 per cent.

Table I presents a fairly conservative analysis of airborne ECM production expenditures for the next decade. Spaceborne equipment, Table I also shows, will begin to claim a major slice of the ECM production dollar during the late sixties. Aircraft ECM will continue to take the lion's share for the next five or six years.

Right now, ECM contractors are still trying to rebound from the debacle of the ALQ-27 cancellation. According to at least one major ECM firm, this cutback set off a negative chain reaction—even so promising an area as electronic recon reportedly has been slumping

more on next page



Jim Holahan and Bern Kovit

THIS SPECIAL REPORT is designed as a comprehensive review of developments and trends in one of the most important, interesting, complex, and yet least written-about phases of electronics. Raw data for this report were virtually non-existent in the technical literature. They had to be gotten by personal contacts with electronic-warfare specialists in the military, in the industry and at universities. All told, SPACE/AERONAUTICS interviewed some 40 of the top scientists and engineers in ECM, ECCM, and electronic recon.

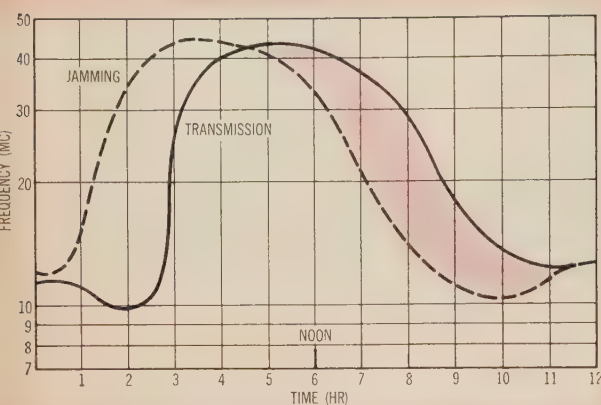
Electronics editors Jim Holahan and Bern Kovit did most of the work on this special report, with assists from associate editors Irwin Stambler and Bob Loebelson, who took care of much of the West Coast and Washington coverage, respectively. As a special feature, Jim and Bern compiled a "directory" showing the activities and capabilities of contractors, universities, and the military in the ECM field.

A limited number of reprints of this special report is available to meet single-copy and small-lot orders. For bulk orders, special rates will be quoted. In either case, please write to Reprint Dept., SPACE/AERONAUTICS, 205 E. 42nd St., New York 17, N. Y. Orders probably will be filled late in May.

SPACE/AERONAUTICS' special report begins with this article. Other features of the report are:

Tools and Techniques of Electronic Warfare	126
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Simulator Checks Out Radio-Radar AJ Operation	157
Wide Bandwidths, High Power Handling Abilities Needed for ECM Antennas	171
Industry Capabilities	183

Randolph Hawthorne
EDITOR



PROPAGATION DIVERSITY may beat communications jamming. The Voice of America reports that, at certain times of day (usually around noon), ionospheric conditions make it possible for ionospheric-scatter transmission to reach Moscow despite the Reds' tremendous jamming efforts. As this graph shows, transmission on 12 mc could elude jamming for a considerable period.

slumping as the expected funding isn't coming through.

What makes the fate of the ALQ-27 so poignant is that the decision to build a fully integrated airborne ECM system had come only after a long struggle by ECM engineering purists. It represented a major coup for those who argued for advancing the state of art—rather than of adhering to the traditional method of GFE'ing black boxes into an airplane.

The decision to kill the ALQ-27 and B-70 ECM systems reportedly was prompted mainly by looming costs; but optimism about new missiles contributed, too. In particular, our rapid progress on the air-launched ballistic missile (ALBM) was advanced as an argument against giving bombers deep-penetration capability. One ALQ-27 would have cost about \$1.5 million; its substitute, made up of off-the-shelf black boxes, will come to about \$700,000.

ECM progress depends on components

Progress in ECM largely depends on component development, particularly when it comes to tubes. Bill Rambeau, of Stanford University's Electronics Lab, told SPACE/AERONAUTICS that new tube types have made many ECM designs obsolete.

ECM represents a major market for tubes in all military categories. For some specialized devices like traveling-wave tubes, backward-wave oscillators, and carcinotrons, ECM is the principal market.

There appears to be a definite trend, however, toward reduced spending on components. With short production runs, the advent of standardized solid-state devices, and microcircuitry and molecular electronics perhaps only a few years off, it's actually not surprising that expenditures on today's components appear to be going down.

As Henry Bisschop, ECM chief in DOD's Defense

Research and Engineering Office, points out, the big money is being committed for big systems. USAF has been doing most of the spending on R&D and hardware, he notes, but the Navy is rapidly drawing even, with the Army running third. In procurement, the Air Force is far and away the leader. The biggest user of ECM gear, of course, is SAC.

GE's Light Military Electronics Dept. estimates that about 30-50 per cent of all ECM funds goes into R&D. This year, says GE-LMED, about 35 per cent was spent on airborne ECM R&D. Reportedly, we have already used up the \$100 million allocated for overall ECM R&D in fiscal 1960. Bisschop reveals that production money is being used to fund R&D.

Big electronics firms lead ECM field

The following firms are generally considered in the major-contractor category in ECM: AIL, Collins, GE, Hallicrafters, Hoffman, ITT Labs, Litton, RCA, Raytheon, Sperry and Sylvania. (See also *"Industry Capabilities,"* p. 183). A number of people in the industry and the military told SPACE/AERONAUTICS that they believe more large firms as well as a number of smaller ones would very likely be entering the field in the near future.

It's probably much simpler for a large electronics firm to get into ECM than for a small one. For one thing, since ECM uses much standard electronic hardware, chances are the large firm can point to some prior interest in the field. Actually, in some cases large firms have been awarded important ECM systems contracts without much previous experience.

There is some logic to the military's decision to underwrite the strong entry of the electronics giants into the ECM field. To begin with, it puts more minds to work on some of the crucial technical problems. Also it establishes extensive engineering and production capabilities in a field that might have to go into large-scale crash programs practically overnight.

Some expect business to fall off

Most companies covered in SPACE/AERONAUTICS' survey of the ECM field believe ECM will become still more important. Some, though, expect the ECM business to fall off. Dr. E. G. Schneider, vice president for research and engineering at Sylvania Electric Systems Div. told SPACE/AERONAUTICS that the trend in ECM will be downward as we go more into missiles. He points out that:

- shorter-range missiles are already being guided inertially;
- within 5-10 years, ICBMs will be guided inertially;
- there is no need for ECM on ballistic missiles so long as there is no anti-missile missile.

Schneider concedes that ground-based ECM is needed to mess up recon satellites and similar orbital vehicles. "There is still going to be an appreciable ECM business," he concludes, "but it won't be too large." Seeing no future in airborne ECM, Schneider expects that many of Sylvania's ECM people will be shifted from this area.

Taking the more optimistic view, Bisschop pointed out that, since everything about ballistic missile defense is electronic, ECM should play a large part in both ICBM offense and defense. M. M. Barclay, chief of the Electronics Defense Branch of Wright Air Development Division's Weapons Guidance Lab, for his

part thinks ECM will be more important in space, because there we will rely more on electronics. (He also notes that WADD has been responsible for almost all USAF's airborne ECM and will play a similar role for space ECM.)

ECM future depends on IG and AMM

The big question marks in ECM's future apparently are the anti-missile missile and inertial guidance: A successful "auntie" would offer new opportunities for ECM, while the wide use of inertial guidance for controlling missiles and space vehicles would sharply depress the ECM market.

Because it provides the basic means for gathering data for offensive as well as defensive purposes, radar has been the major medium for both ECM and ECCM. Most experts queried by SPACE/AERONAUTICS agreed, for instance, that ECCM accounts for about 10-25 per cent of the total cost of our military radar. The cost of the anti-jam features in a modern radar, EIA president D. R. Hull estimates, may be up to 15 per cent of the overall figure.

ECM has probably been a major influence in advances in the state of radar art. Actually, good radar design, seeking to minimize all noise, is good ECCM.

The major trend in jamming radar is away from the brute-force power jammers to more sophisticated and deceptive devices. These have up to now cost more to produce and proved more complex and therefore heavier. Deceptive radar device with no more weight and bulk than conventional jammers would mark a big advance in airborne ECM.

Among the technical problems besetting ECM, maintenance looms large, since ECM gear is generally more

complex than conventional electronic equipment. Some ECM engineers actually admit that their designs generally are really hard to keep operable. Good, simple checkout equipment therefore should find a profitable market in ECM.

The ECM simulator field seems to be fairly wide open, too. A good ECM simulator is very expensive. It usually includes a computer for the evaluation of operational test data before flight testing.

Of the various deceptive decoys used in ECM, the most realistic is the small, aircraft-like vehicle launched from conventional bombers. It can be fitted with corner reflectors and other radar-signal enhancement devices to give it a radar cross-section comparable to that of a much larger aircraft.

The attacker would launch decoys of this type from beyond the normal radar detection range. The result would be dispersion and overloading of the defensive systems when the real raid takes place. An example of a decoy suited to this kind of a mission is the McDonnell Quail.

Decoys are relatively expensive

The main drawback of such decoys is that they are relatively expensive and that a bomber can't carry many of them. They may also lose much of their usefulness as ALBMs become operational.

Chaff, which has been the passive decoy standby since early in World War II continues to be fairly well funded. However, few aircraft can carry enough chaff for missions of any length.

Aerial and satellite recon are areas in which the future of electronic warfare design seems particularly

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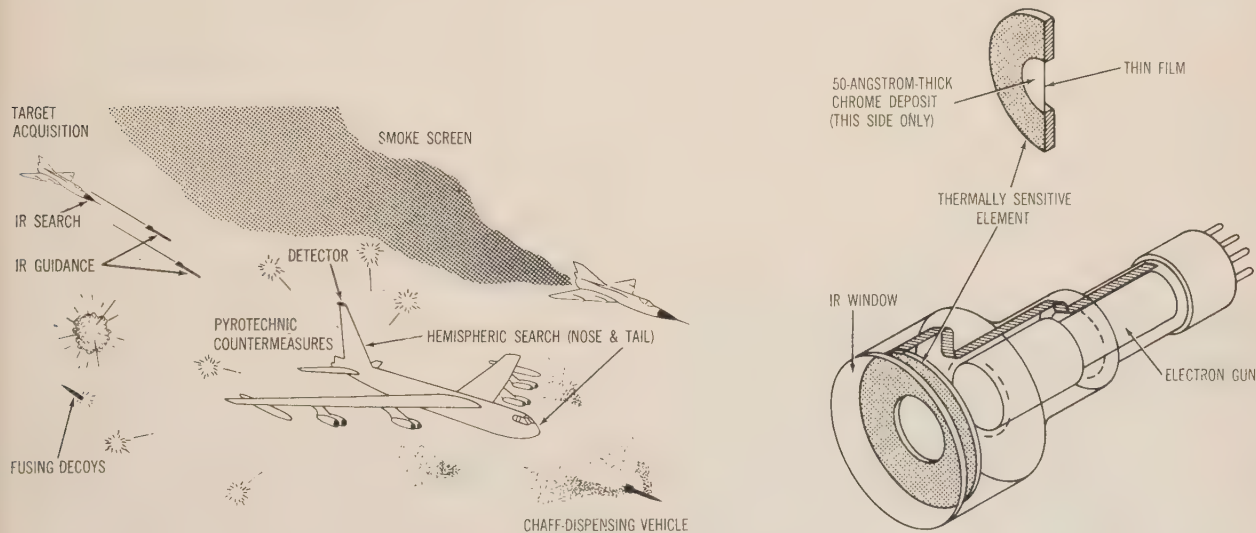


FIGURE 2: The common bag of tricks for infrared defense (left). Various means of making yourself look cooler to an IR missile may also be used. The attacker's weapons for their part may rely on IR CCM, such as spectrum- and possibly intensity-sensitive discrimination

circuitry in both fire control systems and missile IR seekers. Right: "Ultimate IR detector" is the thermal-image vidicon, according to Avion. Much R&D money is being spent on detectors, mainly by Aerojet-General, Avion, GE-LMED, Hughes Aircraft, and Philco.

Table 1: The Market for Airborne ECM

Estimated Expenditures (millions of dollars)

	'60	'61	'62	'63	'64	'65	'66	'67	'68	'69
AF and Navy aircraft ¹	140	140	130	130	121	98	56	30	10	16
Army aviation & light ground equipment	17	17	20	20	20	20	20	20	20	20
Missiles ²	3.6	13	19	19	21	29	32	35	37	37
Space Projects ³	16.5	12	11	13	12	18	39	63	73	77
Total	177.1	182	180	182	174	165	147	148	149	150

(1) Assuming the B-70 is dead for good. If it were revived, figures would increase drastically. (2) Successful application of inertial guidance probably would lower the estimates for the early sixties by at least 30 per cent. On the other hand, the development of an effective anti-missile missile would sharply increase the figures. (3) Largely R&D through 1962.

well assured. Actually, ECM and ECCM systems both simply could not operate without the intelligence that must be provided by electronic recon.

Another major ECM application is the establishment of a continent-wide network of huge, jam-resistant, frequency-diversity radars for detecting and tracking ICBMs. Avco-Crosley, GE, Raytheon, Sperry, and Westinghouse, are the prime contractors selected by the Air Force to get such a program underway. Initial funding has climbed to well over \$150 million. Several of the high power, long-range FD radars will guard a given sector with overlapping coverage. Each will operate in a different band, and despite its huge size, be able to switch frequencies very rapidly, it is claimed.

ARM opens up new possibilities

An extensive future market for both offensive and defensive ECM may be opened by the anti-radar missile. Should this advanced weapon become hardware, its mission would be to home in on and destroy ground-based radars. One engineer told SPACE/AERONAUTICS that he could off-hand figure out at least five rounds of countermeasures and counter-countermeasures that would apply to this problem (still leaving the missile with a reasonable chance).

Acoustic countermeasures against sonar make up a very specialized field. During World War II large "Alka-Seltzer" tablets were sometimes released by submerged German subs to produce a storm of bubbles which were comparable in a sense to the chaff used to mask radar targets. The sonar operators could tell the bubble population from the sub by relying on Doppler shift, since the sub was traveling at a faster rate.

Another sonar countermeasure is the decoy torpedo. It is usually quite noisy, so that it will be detected by passive as well as active sonar.

Actually it's reasonable to assume that countermeasures are not needed as badly as against sonar as against the natural undersea noises which do quite a jamming job on sonar all by themselves.

Infrared countermeasure offers a varied bag of tricks. According to Ed Stark, head of the IR Research Group at Sperry Gyroscope, the importance of IR countermeasures will increase as we go from manned to unmanned weapons.

IR warning system is under study

Figure 2 shows some of the techniques used or considered for IR countermeasures. Other are:

- Make yourself look cool to an attacking IR seeker by using an insulating shield in the area of the afterburner (if you carry a jet engine) or by deflecting exhaust gases.

- Cut out the afterburner during the attack, spray yourself with streams of coolant (water ?), throw out smoke screens.

- Set off flares at various points on your aircraft to confuse the IR seeker with several heat sources of varying intensity.

- Inject a hotter-burning chemical (boron ?) into the engine during attack to confuse avoidance circuitry.

- Place a nuclear radiating source or cloud in the seeker's path to confuse the seeker's electronics.

- Focus electromagnetic energy on the attacking IR missile, setting up a strong field at the homer electronics. (This technique depends on continuing progress in microwave amplification and focusing.)

The most commonly used IR countermeasure is the pyrotechnic flare. A passive IR countermeasure is the release of chaff. According to Stark, much R&D is being devoted to developing an IR warning system that will provide intelligence on the kind of attack the enemy is mounting as well as signal the attack itself. Some way of figuring the direction and closing rate of an attacker spotted by IR is also needed, he says.

ECM management is a major problem

It may be a necessary evil or it may be just a tradition, but in any case disorganized management is one of the major problems in ECM. Interviewed by SPACE/AERONAUTICS, engineers from several companies commented on the way matters are being handled in ECM, and not always in a complimentary fashion. Most of their gripes were concerned with three particularly sore points:

- Intelligence isn't filtering down.
- Funding and contract awards are not being handled properly.
- The military and industry fail to coordinate.

The amount of trouble to which most ECM contractors must go to get information that is absolutely essential if they are to come up with effective designs is thoroughly discouraging. One engineer told SPACE/AERONAUTICS that ECM firms spend much of their time setting up private lines of intelligence. Many people in the ECM field also are quite emphatic in their charges of "information bottlenecks" and "oversecurity."

To help speed up the flow of information, the military has begun to sponsor less formal (though classified) industry meetings on ECM developments here and abroad. Annual symposia of this type are already being held at Johns Hopkins, Michigan, and Stanford Universities.

A deficiency in technical management and military-industry coordination is pointed up by Dr. H. W. Welch of Motorola. He echoes the fears of many in the ECM field when he poses his problem: With so much radar equipment concentrated in the same frequency, what would happen in time of war if a great deal of the equipment went on at once? The way things are going, Welch believes, when we turn all that radar on, we'll jam it ourselves. Obviously, what is needed is for the sole ECM customer, the military, to set up some form of spectrum control, Welch concludes.

Pentagon set up advisory group

A major step toward more effective military-industry coordination and project direction was the establishment by DOD of an advisory group on electronic warfare. Chaired by Dr. Gene Fubini, of AIL, the group is made up of eight industry consultants. Six working panels also consisting of industry consultants, are being set up on: recon; test and evaluation; electronic systems; propagation, radiators, and antennas; sensors, EDP, and display; and jamming, deception, and vulnerability (including ECM techniques). Right now, an *ad hoc* group is looking into the ECM vulnerability of data link.

When the military and industry really worked together on managing an ECM project, the results have been outstanding. A case in point is a sizeable ECM modification program for which Tamar Electronics was the contractor (*Table II*). For the vast majority of ECM projects, time obviously is not as important as it was for Tamar's. Nevertheless the teamwork concept worked out by Tamar could be generally valuable for satisfying the military in ECM and raising industry's skills and morale.

An important factor in our electronic warfare effort—especially in ECCM—is the Soviet's capabilities. The effective jamming of the Voice of America (VOA) and Radio Free Europe have taught us a healthy respect for what the Russians can do in ECM. Some experts think that they are at least equal to us in this field.

VOA transmissions are cut to 10%

According to VOA director George Jacobs, the Reds have several thousand jammers in use—both local and long distance types. The latter are propagation scatter designs. This array of ECM gear cuts down the percentage of our transmissions getting through to Moscow to about 10 per cent at best. The type of jamming maneuvers the Soviets are able to pull, our experts believe, reflect an advanced and truly professional jamming technology.

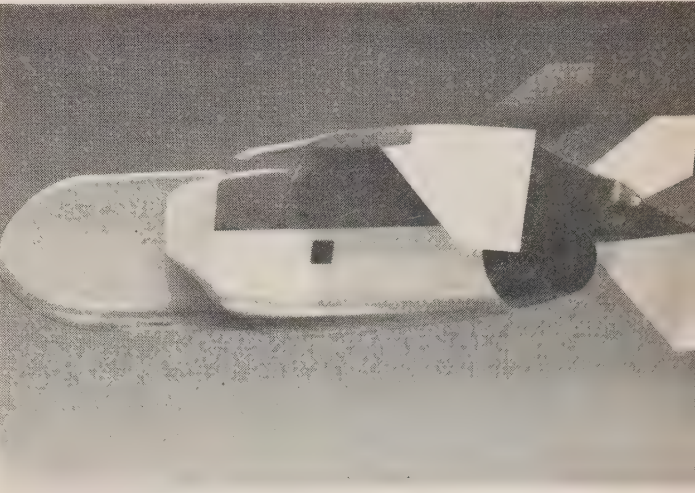
VOA-sponsored research groups have been studying means of overcoming the Reds' jamming. So far, only one method seems to produce any results—propagation diversity (*Fig. 1*). With this technique, you set up as many transmitters at as many distant points as possible and take advantage of the difficulty of jamming signals from many sources that transmit only when ionospheric-bending conditions are favorable to the sender.

Two figures give you an idea of what their vast jamming effort is costing the Soviets: (1) They must pay about \$6000 a year to keep a single 100-kw transmitter running for just one hour every day. (2) The cost of putting just one kilowatt-hour into all their thousands of systems has been estimated at around half a million dollars.—End

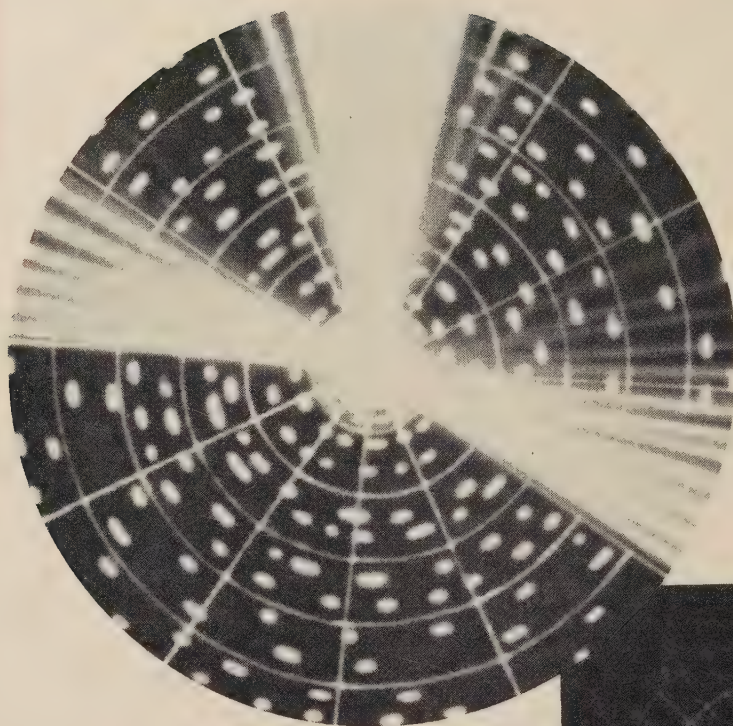
Table II: Military-Industry Team for Efficient ECM System Development

Military Activity	Steps in Typical Development Program	Contractor Activity
Formulated by operational command on the basis of operational analysis of national strategy, tactical doctrine, and state of the art	Operational Requirement	Assists by presenting new concepts showing requirement to be technically feasible
Formulated by materiel command on the basis of analysis of the operational requirement in the light of technical feasibility	Performance Specification	Assists by studies to show the degree of technical feasibility and reliability
Materiel command awards contract, reviews results, decides whether a further effort is warranted	Preliminary Designs	Assumes responsibility under the terms of the contract
Materiel command awards contract, reviews design data, arranges for support by government facilities	Prototype Development	Completes detail design under the terms of the contract
Test command provides facilities, controls safety, security, and scheduling of tests	Development Flight Tests	Plans and monitors the test program
Materiel command awards contract, monitors changes from prototype	System Production	Assumes responsibility under the terms of the contract
Operational command plans and carries out missions	Operational Performance	Renders advisory and support services

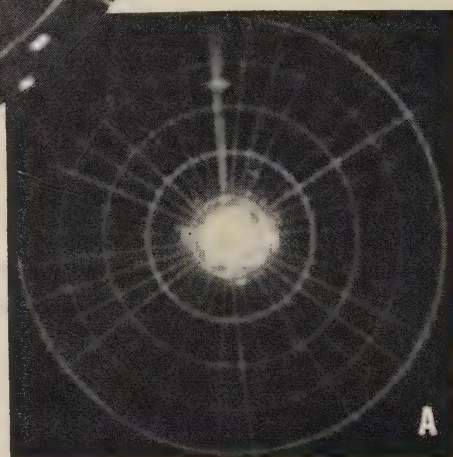
SQUAT, ANGULAR shape and bulbous nose give McDonnell's GAM-72 Quail decoy a relatively large radar cross-section. The Quail's equipment may include corner reflectors, a Luneberg lens, and probably a barrage or rapid-sweep-through jammer.



2



Tools and techniques of **electronic warfare**



WHICH is the target? Drawing by Sperry Gyroscope's Countermeasures Group (top left) shows how a PPI would look with a combination of noise and false-target jamming. The noise is coming from three locations. The reason for the broad seg-

- Sophisticated ECM designs are still in the lab stage
- RF-power-generating system is the key to good ECM
- Advanced radars are ECM tools in themselves

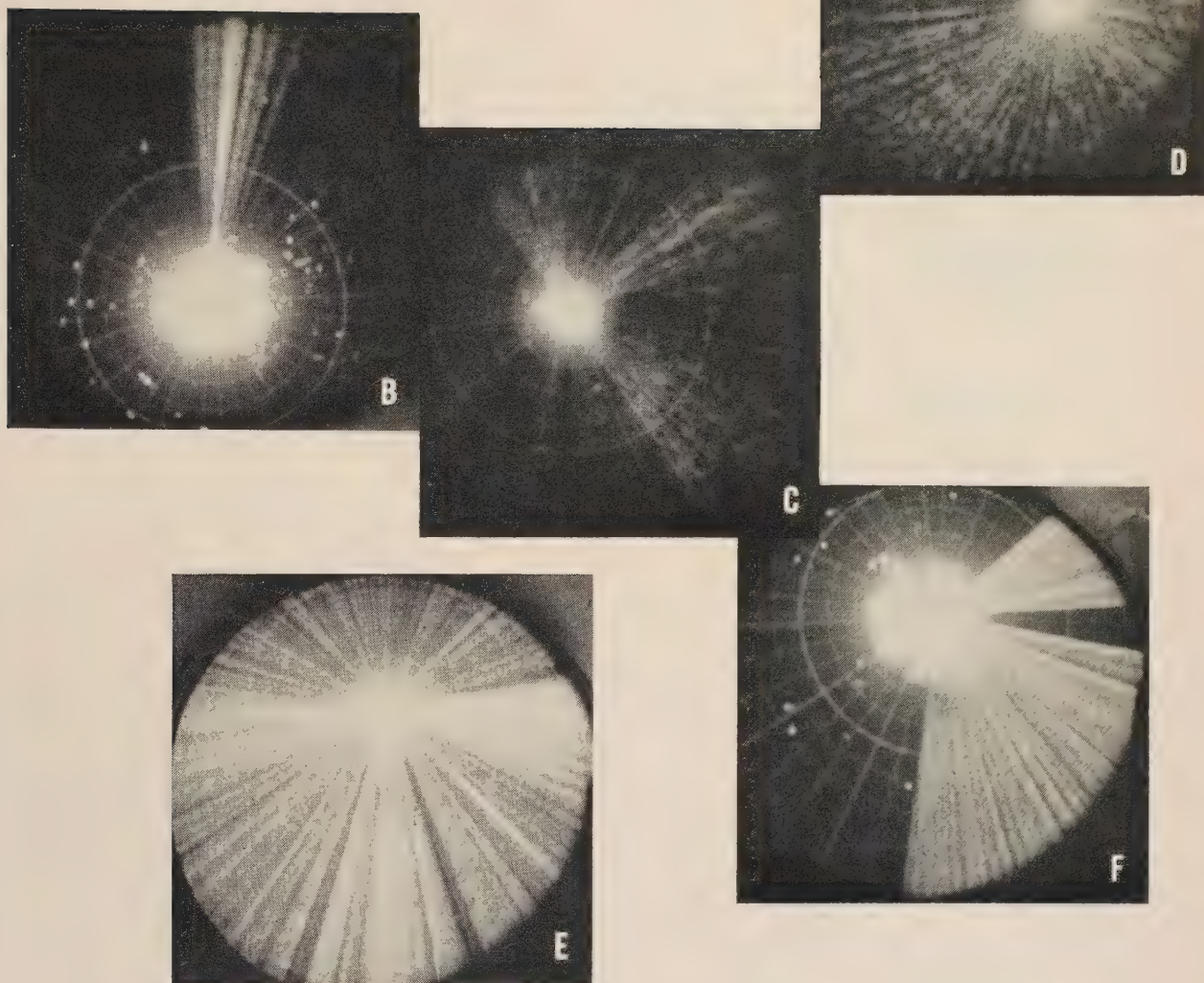
by **James Holahan**, Electronics Editor

OUR ELECTRONIC countermeasures (ECM) today, whether in operation or in development, are aimed mainly at radar and communications. There is also a medium-sized and growing program in infra-red ECM, and the first steps have been taken on ECM against radio navigation aids.

Radar, because it is the military's principal means of data gathering, accounted for the greatest portion by far of our ECM effort and dollars. And the major area in radar ECM has been airborne systems for manned bombers.

The trend in ECM design is away from brute-force noise jamming and toward "educated" and integrated systems. The final goal is automatic, self-programed designs.

Today, though, a SPACE/AERONAUTICS industry survey shows, the sophisticated ECM techniques with a



ments is that the jamming is entering the radar's side lobes as well as main lobes. Bottom left and above: Typical noise jamming against a single search radar is shown by photos taken by ECM engineers at GE Light Military Electronics' Advanced Research Center. Both A and B show strobes caused by the jammer. These are not very

effective. (The target is plainly visible in A.) The higher degree of jamming in C and D could be due to increased jammer power or radar sensitivity or to poor radar antenna characteristics. Complete jamming is shown in E. The effect is the same in F, except that the jamming is limited to certain sectors.

few exceptions are still in the lab stages. For our operation systems, we are relying almost exclusively on brute-force methods—noise jamming and chaff dispensers.

The only approach so far to an integrated ECM system is that used on the Convair B-58. Developed over five years ago and now being produced by Sylvania, this system is made up of three subsystems: radar sensor, jammers, and chaff dispenser. Its operation can be either automatic or manual.

Radar ECM may be very arbitrarily divided into two types by their results: confusion and deception. In both cases, obviously, the aim is to blank out, delay, or down-grade the enemy's radar-derived data. The difference between the two cases arises because the enemy normally knows when he is being confused but not when he is being deceived. (In deception, he is fed false data that he thinks are correct.)

Deception techniques include repeater jammers, transponders, inverse gain, and gate stealers.

Confusion techniques include active, wide- and narrow-band noise jammers, multiple-target generators, decoys, and chaff. Most known active confusion jammers rely on penetrating the major and minor lobes of the radar's radiation.

Barrage jamming is the common name given to wide-band noise generators. Its advantage is that the jammer needs to know little or nothing about the radars it is attempting to jam. Barrage jamming also is effective against all known types of modulation and signal processing, provided it has a healthy power advantage over the radar signals. On the other hand, barrage jamming wastes power, interferes with friendly electronic measures, and is detected easily by passive direction finders.

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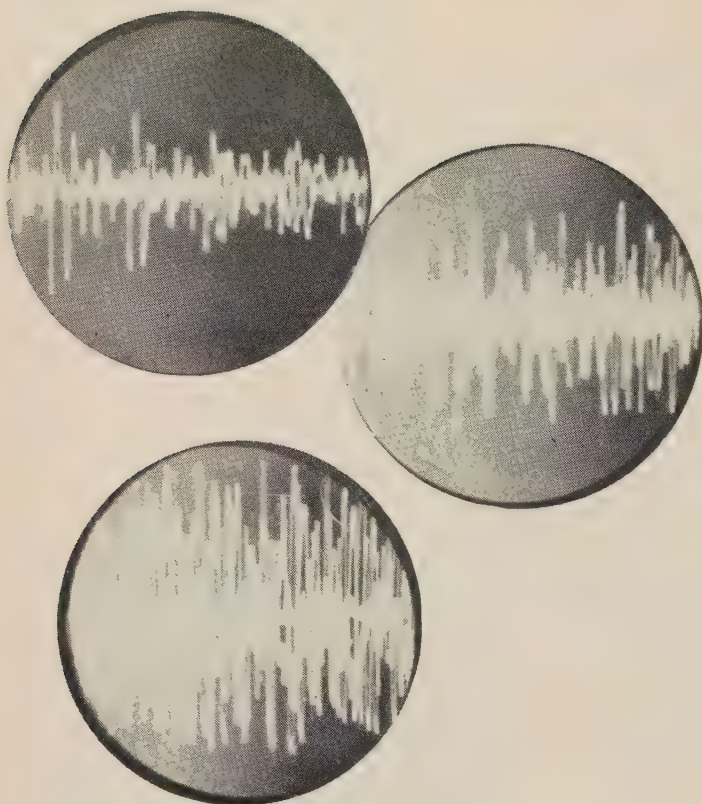


FIGURE 1: Photos of Soviet jamming of a Voice of America program broadcast from Tangier, Morocco, and received in Switzerland shows signal transmitted in the 21-mc band (left), signal just visible in noise shortly after jamming had started (right), and jamming at full intensity (bottom).

The main reason for the wide use of noise modulation in ECM is that any intelligence transmission is a probability function of the signal-to-noise ratio. Early receivers could be jammed even when the jamming-to-radar-signal ratio (J/S) was below 1 db at the receiver input. With newer receivers, this ratio in many cases has to be many decibels in favor of the jammer.

Known schemes for letting the receiver recover the signal from noise trade time for detectability. Given enough time, the receivers theoretically can see through any amount of noise jamming. Practically, it is limited to very short integrating periods, because of factors like target velocity, scan rate, hits per pulse, and the design problems of long-time integrators.

Jamming on one or several specific frequencies is called "spot jamming." To conserve energy, the jamming signal is tailored to the bandpass of the victim. Many types of modulation are used: AM, FM, noise, stepped tones, CW, etc.

The oldest confusion device, chaff, still ranks high with the military. New ways of coating, packaging, and dispensing it are being worked on. Forward-shot chaff can be used to deceive range and velocity tracking gates. Most of USAF's chaff testing is done at Malabar, Fla., on a range operated for RADC by Radiation, Inc. This company is also doing extensive work on missile and aircraft reflectivity measurements.

The multiple-target generator, another important confusion device, sends back many returns during the interpulse interval of a pulse radar for each received pulse. The radar display would thus show a string of targets for each true return. By penetrating the radar's sidelobes, these can be spread out all over the scope, confusing the operator and saturating any data processing system connected to the radar.

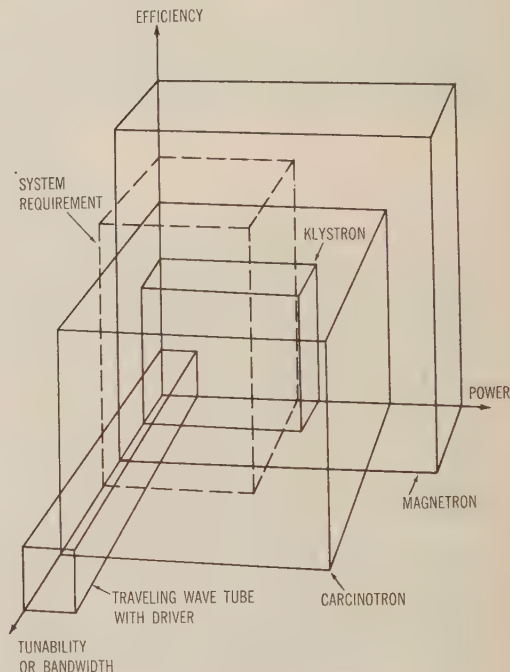


FIGURE 2: Choice of RF power source is the major problem confronting the jammer designer. Here microwave sources are compared for tunability, power, and efficiency with an arbitrary system requirement. None fully meets all the requirements, so the designer must make the best compromise. Other considerations are modulability, weight and size of the tube and of associated equipment (power supplies, etc.), and reliability in severe environment.

ECM engineers at Rome (N. Y.) Air Development Center have made detailed studies of the displays that most befuddle radar operators. One of the most confusing displays, they say, is made up of a series of concentric, jagged patterns—it gives the operator no contrasting background to work against, as would a completely blacked or white-out scope.

The synchronous rings are generated by synchronizing the jamming signal to some multiple of the radar's PRF. The jagged effect is produced by getting slightly out of synch. This technique, claims RADC, gives an effective jam power many times greater than the power that is actually used.

"Look-through" techniques, which let you receive the enemy's radar while you're jamming his receiver, have been developed by both BuWeps and WADD for

following frequency changes during jamming. Truly simultaneous looking and jamming raises many technical problems, which mainly have to do with isolation. The methods in use are believed to rely on time-sharing.

Deception devices, as a rule, are more complex than confusion jammers, but also much more efficient in their use of radiated power. The main problem is building these devices in packages as small and reliable as the confusion jammers.

Typical deception schemes are:

- *Repeater Jammers*—These receive radar signals as they are transmitted, amplify them, remodulate them with false information, and almost instantaneously retransmit them on precisely the same frequency at which they were received. Against radars designed to recognize their own wave shape, a true repeater would have to duplicate that shape.

- *Transponder Jammers*—These may be tuned, partially tuned, or untuned. They repeat the impinging radar signal with some delay. Conceivably they could send back either a much larger signal return (indicating a much larger radar cross-section or closer range) or noise jamming.

- *Range Gate Stealers*—These are used when the target senses that it has been acquired by a tracking radar. The stealers return signals with false delay times, thus "telling" the radar that the target is at a range at which it really isn't. The delay could be lengthened or shortened so much that the range servo limits are exceeded and the radar reverts to the search mode.

- *Velocity Gate Stealers*—Against Doppler tracking radars of the pulse, CW, or FM-CW type, frequencies indicating false Doppler shifts could be sent back to falsify the attacker's speed or to pretend that he isn't moving at all. Other methods could take advantage of the small number of targets that known Doppler tracking radars can handle.

- *Angle Track Breaking* — Elevation and azimuth track in sequential-lobing (conical-scan) antenna systems can be broken by transmitting a signal at the nutating frequency. This signal will either confuse the radar antenna servo or prevent it from following.

- *Radar Absorbing Materials (RAM)*—RADC and Naval Research Lab scientists have been searching for years for a material that will shrink the radar cross-section of aircraft and missiles and make them partially or fully invisible. The problem is finding a material that will absorb impinging radar signals and/or scatter them from the vehicle. Such a material must be (1) thin and light, or it will seriously compromise the flight characteristics of the vehicle; (2) rugged enough for high speed environments; (3) five or six octaves wide in bandwidth in the microwave region.

Even partial invisibility helps

Several classified materials look promising, though they appear to be feasible only for subsonic vehicles. However, a hard-to-see "slow" vehicle may be much better as a weapon than a fast one that sticks out like a sore thumb on the radar screen.

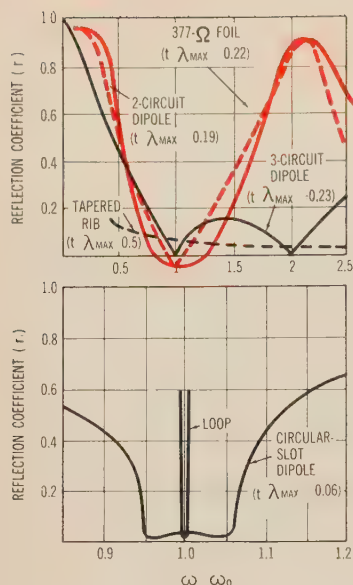
Even partial invisibility is helpful, says the Air Research & Development Command. It points out that, if an RAM-coated missile could attenuate the power of impinging radar signals by just 12 db (so that 94 per cent of the signal power is absorbed), this would have the same effect as cutting the range of the observing radar in half. A vehicle with a reduced radar cross-

more on next page

Table 1: Possible Anti-Jam Techniques*

Basis of Technique	Technique
Spatial selectivity —uses direction or entrance path to distinguish signal from jamming	side lobe reduction, side lobe blanking
Frequency selectivity —discriminates against wide-band, off-frequency, and impulsive signals; also uses velocity discrimination	proper tuning, tunability, filtering, balanced mixing, frequency discriminators, Lamb suppressor, MTI, Doppler shift detection
Amplitude selectivity —uses amplitude characteristics of signal to discriminate against such interference as high energy or impulsive signals or noise	limiting, Lamb suppressor, side lobe blanking, log amplifier, IAGC, detector balanced bias
Time selectivity —uses time of arrival of signal or time separation between successive returns to distinguish between jamming and target returns	pulse interference separator and blanker, delay line integration, Lamb suppressor, STC
Signal selectivity —uses signal statistics, shape, spectrum, or polarization	IAGC, FTC, detector balanced bias, circular polarization, optimum filtering, pulse shape discrimination, coherent detection, delay line integration, some unconventional modes of operation like complex waveforms, triangular FM systems, binary-coded PM waveforms, pulse compression, noise correlation

* Adapted from D. B. Brick & J. Galejs, "Radar Interference and Its Reduction," Sylvania Technologist, July '58.



REFLECTION coefficient as a function of frequency for several absorber types for which the ratio of thickness to maximum wavelength at which $|r|$ equals 1 is given. The wavelength is 11 cm at $\omega/\omega_0 = 1$ and 5.5 cm at $\omega/\omega_0 = 2$. Absorbers of these types are being studied at the University of Göttingen, Germany, for RADC.

section also would need less jamming power to screen itself, as the jamming education shows.

Most of the absorbers under consideration are based on transmission line theory. A promising new class is based on the electric dipole moment of the molecules of certain liquids. The problem in this case is finding the right binder material.

- **Radar Camouflage**—RAM, corner reflectors, Luneberg lenses, and transponders can be used to mask ground targets from aerial radars or to set up dummy replicas of landmarks or targets. Buildings can be contoured to give stronger or weaker returns—certain features can be softened with RAM, others can be accentuated with reflectors.

- **Inverse Gain Control**—In this technique, signals are sent back whose strengths are inversely proportional to those of the impinging radar signals.

RF power generation is the key

The ECM engineer must have a thorough technical knowledge of the equipment he is trying to counter—not only of the sensor (i.e., the radar) but also of the entire system in back of it (automatic programming, data processing, etc.). One pitfall, warns Don Beilman, supervisor of ECM engineering at the Advanced Electronics Center of GE's Light Military Electronics Dept., is to design your ECM device around a weakness of the defense that can be eliminated by relatively simple design fixes. What you should do, says Beilman, is to aim at an inherent weakness of the defense that can't be corrected except by major modification or a completely new design approach.

The keystone of ECM design is the RF-power-generating system. Whether it is airborne or ground-based, this system more often than not will be power-limited. The greatest need therefore is for high average power generating devices to cover the usable UHF and microwave spectrum.

True, not all jammers must radiate high powers—actually, a few watts goes a long way under certain conditions, because of the $1/R^2$ vs $1R^4$ advantage of the jammer (see "Good Design Can Beat the ECM Threat," p. 138). However, the trend in radars is toward much higher powers and to techniques that in-

crease sub-jamming visibility. The direct way of coping with these trends is higher ECM transmitter powers.

To make the most efficient use of the available energy, the ECM designer often tries to concentrate the power he does have in space, frequency, or time. Usually discrimination in any of these categories requires a knowledge of the defense radar's characteristics or intelligent signal analysis circuits.

In ECM as in radar, two types of power-generating systems are used: the power oscillator and the modulated oscillator-power amplifier (MOPA). The former uses magnetrons or carcinotrons and, of late, barratrons (a type of magnetron operated in an unstable mode).

MOPA modulation at low levels

To date, the fixed-tuned (narrow- and wide-band) jammers use the magnetron. Its advantages are simplicity, low cost, availability, low weight, and high efficiency (over 70 per cent). Where rapid frequency tuning is desired, the carcinotron is used. It has a high power output (100-800 kw average), is highly efficient (over 50 per cent), and tunes rapidly (to 100 mc/usec). It is quite expensive, however.

The main drawback of power oscillators for ECM is that they have to be modulated at high levels. This means high voltages and large power supplies. It also restricts the designer in the number and type of modulation schemes he can use.

In the MOPA, a low-power oscillator like an O-type backward-wave oscillator (BWO) or a voltage-tuned magnetron (VTM) drives a string of high-power traveling-wave tubes (TWTs) in cascade. The BWO and VTM are voltage-tuned and can be rapidly scanned over an octave in frequency. Modulation is done at low levels, so there's virtually no limit to the tricks the designer can apply. (Figure 2 compares characteristics of the magnetron, carcinotron, TWT, and kylstron. The last tube is of limited usefulness in ECM, because of its relatively small electronically tuned range.)

The trend in ECM transmitters has been to the MOPA. It was clearly shown by the three most advanced systems yet planned by USAF: those for the Convair B-58, Boeing B-52H, and NAA B-70. (Only the first of these is still in being; the other two have been canceled.)

The "electronic shield" being produced by Sylvania for the B-58 apparently represents the first real effort to develop an integrated, advanced airborne ECM system. Though, neither USAF nor Sylvania has said so publicly, the "special microwave tubes" that the company announced it developed for the system are TWT power amplifiers and O-type BWOs, according to industry sources.

The canceled ALQ-27, which was developed by Sperry for the B-52H, shaped up as one of the major markets for TWT makers. A family of rugged TWT amplifiers and distributed amplifiers (for below UHF) was designed specially for this system.

The ECM system proposed by Westinghouse for the B-70, observers comment was due to take up where the ALQ-27 left off. It's a safe bet, therefore, to assume that the system was built around the TWT.

The cancellation of the ALQ-27 and B-70 ECM systems may mean at least a temporary setback for sophisticated airborne ECM. WADD will manage a replacement system for the B-52H that apparently will use available hardware and few advanced techniques. Many

observers believe that USAF's interest in the TWT as an amplifier for high powered ECM systems has cooled off.

The high weight, low efficiency (about 10 per cent at high powers), and relatively high cost of the tube are the main reasons. Most current high power TWTs use electromagnets for focusing. These are quite heavy, especially at the lower frequencies (L-band). Permanent magnet period focusing looks promising for weight reduction and may solve the problem. It has worked out in low power tubes and is now being applied to higher-powered ones. Another technique is electrostatic focusing; however, it raises the power supply weight.

What is needed is a microwave amplifier with an average output between 0.8 and 1.5 kw, 50 per cent efficiency, and at least a 2:1 bandwidth. Efficiency is extremely important in airborne high power amplifiers, since primary power in aerospace vehicles is limited and also because of the cooling problem created by dissipated and unradiated energy.

WADD emphasizes that efficiency is extremely important where high powers are generated, since primary power in aerospace vehicles is limited, and also because of the problem of getting rid of dissipated (unradiated) energy.

Crossed-field forward-wave amplifiers (FWAs) might be one answer. Two M-type FWAs are known to be in development: one by Hughes Aircraft, another by CSF in France. The latter reportedly has a bandwidth of 25 per cent, an average power output, of six kilowatts, and an efficiency of 50 per cent at L-band.

Communications ECM runs a poor second to radar ECM. Part of the reason is that in World War II it was more profitable to eavesdrop on the enemy than to jam him. This situation might be drastically different in a future conflict—secure communications methods now are making it far more difficult to extract intelligence from intercepted signals.

Communications ECM has its own peculiar set of problems, such as:

- In communications, the energy from the defensive equipment is not necessarily beamed at you, as in radar, so quite often you have to look for the signal you want to counter.

- A communications jammer doesn't have the $1/R^2$ vs $1/R^4$ advantage, since signal transmission is over a

one-way path. Quite often, too, the jammer is farther from the enemy's receiver than his transmitter.

- The propagation losses of a battlefield jammer might run as high as $R^4 \cdot R^6$ because of ground absorption, reflection, etc.

- Point-to-point communications are well-nigh impossible to detect, let alone to jam.

- Military communications transmitters use low powers, compared with radars. Also, the time constants in communications are in milliseconds rather than microseconds.

- Most military channels are quite narrow in bandwidth, so that large frequency blocks can be jammed with relatively simple equipment.

Jamming power versus bandwidth

The trend in the military has been to narrow-band circuits to get more channels within a given part of the spectrum. This trend would seem to make the jammer's job easier. The military is apparently hoping the enemy would be using the same parts of the spectrum and would be reluctant to jam over wide bandwidths for fear of self-interference. Military communications experts point out that they can always make up for the vulnerability of narrow-band channels by sending the same message simultaneously over several channels.

Dr. J. P. Costas, of GE's Heavy Military Electronics Dept., is an outspoken critics of this approach. As he sees it, an enemy with unlimited resources and determination can jam any communications system. The trick therefore is to force him—through good design—to expend an unreasonably large effort in jamming. "If the most efficient system design is assumed for a fixed data rate in each case," Costas explains, "the necessary power required to jam the circuit varies in direct proportion to system bandwidth. The broader the bandwidth, the more difficult it will be to jam the circuit. Conversely, the narrower the bandwidth, the easier it becomes to jam the circuit."*

Our experience with the Voice of America shows that the Russians are quite expert at communications jamming. Since 1950, they have been silencing about 90 per cent of VOA's broadcasts to countries behind the

* "Poisson, Shannon and the Radio Amateur;" *Proc. IRE*, Dec. '59.

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TYPICAL random-noise, sweep-through jamming system for L- to X-band.

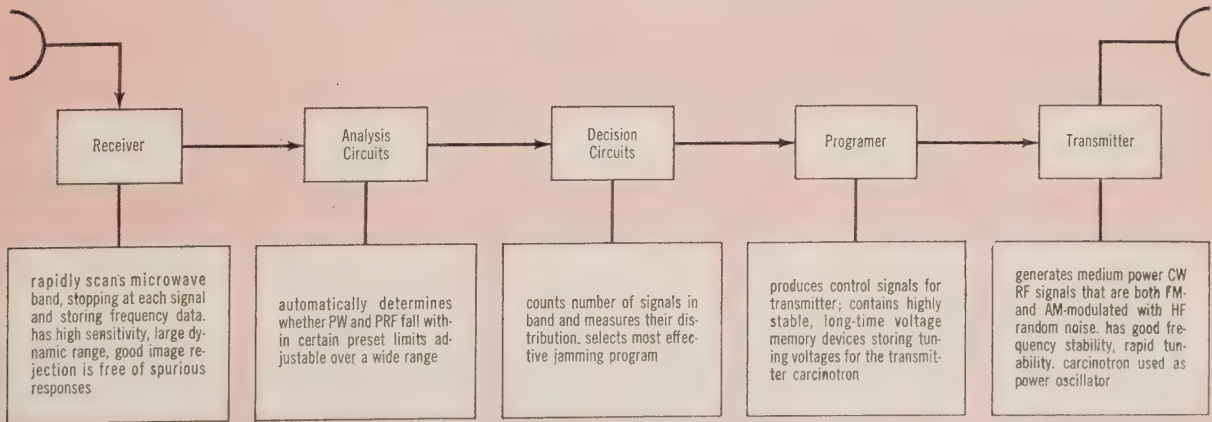


Table II: ECM vs ECCM

Countermeasure	AJ Counter-countermeasure
Low-PRF random pulse jam	pulse delay and comparison with pulse on next sweep and blanking
Wide-band noise Very-high-PRF random pulse jam	increased look time and integrating; antenna pattern with high sidelobe discrimination
CW jam	methods for avoiding saturation (IAGC and the like, followed by FTC and third detector)
Pulse repeater jam	PRF jitter, then as for random pulse jam
Short pulse jam	limiting at output of wide-band front-end
Slow sweep-through jam	as for random narrow pulse jam
Fast sweep-through jam	as for wide-band noise
Decoys	discrimination on basis of reflectivity, mass, and size
Chaff	Doppler shift, acceleration gating
Range gate stealing	Doppler shift, narrow range gate, acceleration gating
Angular track breaking	simultaneous lobing techniques

Iron Curtain. Today they are estimated to have several thousand high-powered jamming transmitters (with outputs as high as ½ Mw) connected by a highly efficient intercept and control network (Fig. 1). Some of these transmitters send their signals over sky waves, others over ground waves. The Red jammers have amazing frequency agility—if VOA jumps to a new frequency, they are right on top of it in seconds.

VOA has studied several possibilities for piercing this electronic curtain, such as higher power, frequency jumping, "cuddle-up" (getting next to an important Russian broadcast station in frequency, so that, in jamming VOA, the Reds would also jam their own station), and propagation diversity. VOA admits it has no feasible method for overcoming ground-wave jamming, but it believes propagation diversity can often beat sky-wave jamming. This technique takes advantage of the difference between ionospheric bending properties seen from Russia and those seen from other parts of the world at certain times of day.

Trend to integral ECCM design

Electronic counter-countermeasures (ECCM) in radar design are commonly referred to as AJ techniques (Table II). While many circuits in modern radars owe their existence to anti-jamming, the trend has been away from "hanging" these circuits on as appendages and toward integrating the ECCM capability into the overhull design.

Since most ECM takes the form of RF interference,

many of the design approaches that give better performance in natural noise and in a high signal environment of friendly radars will also work against ECM. For example, Table I, which shows methods of general "RF interference reduction," is essentially a listing of the basic AJ methods. Actually, discrimination against jamming is always based on one or more of the five types of selectivity listed in Table I: spatial, frequency, amplitude, time, and signal. Some of the precepts for ECCM designs that were advocated by radar engineers interviewed by SPACE/AERONAUTICS are:

- *Use unpredictable operating parameters* — The more orderly a radar is in its operation, the easier it is to predict what it will do next, and consequently the simpler it is to confuse or deceive. Uncertainties in parameters like pulse length, PRF, frequency, modulation, and antenna characteristics make ECM more difficult.

- *Recognize your own signal*—Radars that fit this description are based on information theory. Their AJ capability depends on waveform, spectral, or statistical discrimination. The waveforms used in such radars normally have large bandwidths and time duration products.

- *Use trained operators*—A good operator is hard to confuse or deceive. Two operators observing two redundant radars, with each using more than one type of display (PPI, A-scan, etc.) are proof against a lot of ECM.

- *Operate at reduced performance levels when jammed*—No system should be designed that can't exchange resolution for vulnerability to jamming. A system that breaks down completely after a certain jamming level is reached, is poorly designed.

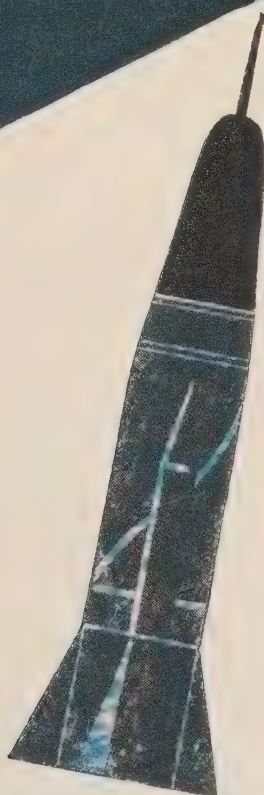
- *Come up with a good basic design*—Provide large dynamic range, a bandwidth just wide enough to receive your pulse, a stable transmitter, large main-to-side and main-to-back lobe ratios in the radiation pattern, etc.

FD is most effective in ECCM

Many of the advanced radars now being built are actually ECCM tools in themselves. Such techniques as pulse compression, noise correlation, pulse-to-pulse frequency or phase change, triangular FM-CW, waveform coding, and matched filters are forcing the ECM designer to apply much more sophisticated equipment.

Radars using these advanced techniques are relatively impervious to both continuous narrow-band swept wide-band noise, but are somewhat susceptible to continuous wide-band noise. However, for jamming, even such noise must match the fine structure of the radar signal, or it will be rejected (unless the jamming signal has a decided power advantage).

Today's most effective ECCM technique is frequency diversity (FD). A family of long range ground-based (FD) radars has already been developed under a multi-million dollar RADC program—GE's FPS-24, Crosley's FPS-26, Westinghouse's FPS-27, Raytheon's FPS-28, and Sperry's FPS-35. Each of these radars operates in a different frequency band, within which it can rapidly shift frequency. Set up with over-lapping coverage to guard a defense sector, a group of such radars represents about the best type of ECCM yet developed.—End



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Electronic dogfight: **ECM vs ECCM** in search radar

- Wide-band jamming keeps down equipment weight and complexity
- Frequency shifting is good countermove to jamming
- Decoy discrimination difficult for radar

by **Peter R. Dax**, Fellow Engineer,
Radar Equipment Engineering, Electronics
Div., Westinghouse Electric Corp.*

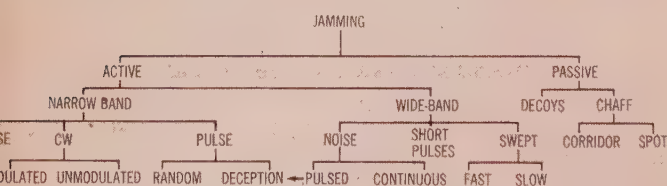


FIGURE 1: Basic jamming methods.

THE CONTEST between electronic countermeasures (ECM) and counter-countermeasures (ECCM) is a highly technical battle whose problems are not always fully understood by the actual contestants in the field. On the other hand, the designer in his lab often fails in understanding, too—when it comes to the practical problems of the contest as it is actually fought out in the field.

What with multiple jammers, multiple radars, and combinations of jam and anti-jam techniques, there's no doubt the situation is rather complex. Take, for example, the basic problems faced by a search radar in a jamming environment and by the airborne jammer that is trying to jam the radar.

The purpose of a radar is to detect targets and determine their position at the greatest possible range. It must report only on *real* targets; and in other words, it must not be deceived by *false* targets.

The purpose of the jammer is to keep the radar from locating a target of interest and possible certain other friendly targets (such as an air-to-surface missile fired at the radar). The jammer does this either by reducing the radar's ability to detect targets or by confusing the radar through the generation of false targets that are hard to tell from real ones. In the latter case, the jammer achieves its purpose by overloading the enemy's data processing system or CIC organization. At the same time, the jammer must try to avoid revealing his presence.

Figure 1 shows the basic jamming methods. In active jamming, the jammer is actually radiating electromagnetic energy. In passive jamming, reflecting material is used to re-radiate energy, generating pseudo-targets where no real ones exist.

*Electronics Div., Westinghouse Electric Corp., Friendship Int'l Airport, P. O. Box 1897, Baltimore 3, Md.

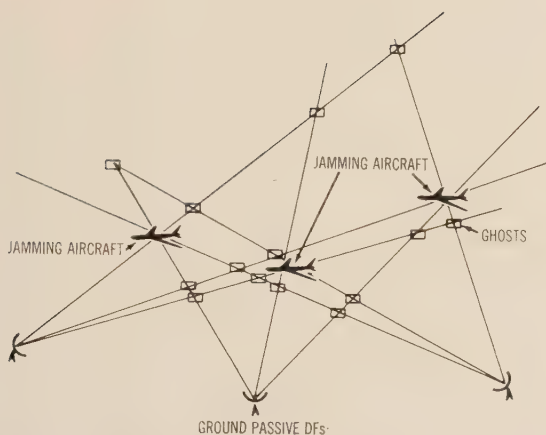


FIGURE 2: Passive direction finders can spot jamming aircraft by taking cross-bearings on their jamming signals. The big problem is ghosts (shown as squares whose centers are the points at which the bearing lines cross but where there are no targets). New designs have succeeded in overcoming the ghost problem.

Active jamming may be narrow- or wide-band. Combinations of jammers can, of course, mix wide-band noise with CW or active with passive jamming, and any form of jamming may be switched on and off intermittently.

A radar may fail to detect a target because of a poor signal-to-noise ratio or because circuit saturation makes it lose the target information. It can also be deceived by false targets generated by random pulses or by deliberate spoofing.

In practice, an increase in background noise will decrease the weak-target detection capability and increase the rate of false target reporting. The probability of detection of a strong target may remain relatively unaffected, however, providing the receiver is not driven into saturation. This saturation, which may take place anywhere in the receiver, will drive the circuits beyond their region of linear operation, and the target information will be lost.

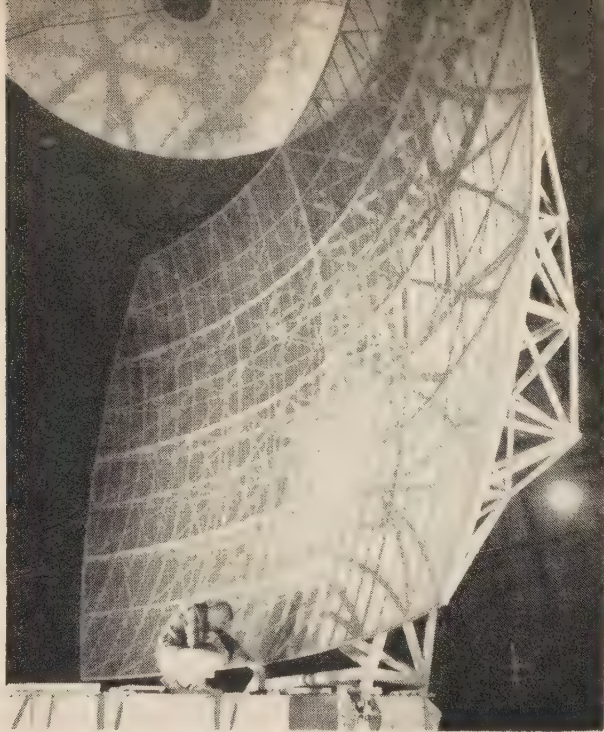
AJ circuitry prevents saturation

One of the main functions of anti-jam (AJ) circuitry, therefore, is to prevent saturation by performing an AGC action that insures that at least the information on targets larger than the background jamming is preserved.

Overloading of a radar by false targets dilutes the radar's capabilities. The result is delays in target processing, which in turn means attacking vehicles will be able to concentrate the defense system more deeply—just as though there had been a loss in detection range.

Certain facts about active jamming must be clearly understood from the beginning:

- The radar receiver is extremely sensitive. It is therefore relatively easy for a jammer to generate RF



FREQUENCY DIVERSITY is one of the trump cards in the hand of the radar designer. USAF is developing a network of search radars that operate in different frequency bands and each of which can quickly change frequency within its band. One of the radars in this group is this Westinghouse FPS-27.

power many times greater than the skin return from the target.

- The radar receiver is sensitive only to a very small range of frequencies. For effective jamming, an appreciable amount of power must fall within the passband of the receiver.

- Weight considerations limit the sophistication of the airborne jamming equipment and the amount of available jamming power.

- If the jammer manages to inject noise into the radar receiver, the result is equivalent to a degradation of the receiver's noise factor. Range performance is proportionally lowered, and no AJ circuitry can improve the situation (assuming the receiver has an optimum bandwidth for the radar pulse).

Active jamming most often is a matter of getting unwanted power into the radar's passband in excess of the power the radar gets from the wanted signal. Let's assume a search radar with a peak power of one megawatt and a 30-db antenna gain is illuminating a target with a radar cross-section of 10 m². In this average situation, the peak re-radiated power (*P*) from the target at a range of 200 km (108 nm) is:

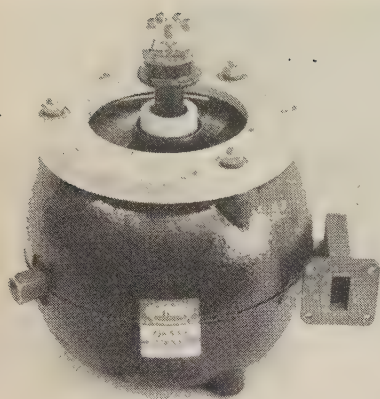
$$P = P_t G \sigma / 4\pi R^2 = (10^6 W \times 10^3 \times 10 m^2) / [4\pi (200 \times 10^3)^2] = 0.02 W,$$

where the symbols are those used in the standard radar equation.

Jammer power increase is lower

Admittedly, it is fairly easy for a jammer to transmit two W/mc, or 100 times the target skin return for our example, over a wide band of frequencies. However, as range decreases, the skin return (as seen from the radar) increases as the reciprocal of the fourth power

more on next page



CARCINOTRON is by far the most widely used variable-frequency power generator of jamming signals in the UHF-to-microwave region. It can tune over a 1.5:1 bandwidth at rates of over 100 mc/usec. Peak power output is well over 100 kw. One form of sweep-through jammer could use a carcinotron modulated by noise to produce a random sweep. The Russians are known to have bought a large supply of carcinotrons in France.

of the range, while the jammer power increases only as the reciprocal of the square of the range:

$$P_{\text{signal}} = P_t G \sigma A / (4\pi R^2)^2,$$

$$P_{\text{jammer}} = P_j B A / 4\pi R^2,$$

where A is the effective antenna area; B , the receiver bandwidth; and P_j , the jammer power per unit bandwidth.

From these equations, it is obvious that at a certain range the skin return is greater than the jamming background and the target becomes detectable. There are several methods for computing this so-called "self-screening range" (R_{sc}). For our example we can assume that the target will be seen when the power of the returned signal equals the jammer power:

$$(P_t G \sigma A / (4\pi R_{sc}^2))^2 = P_j B A / 4\pi R_{sc}^2,$$

$$R_{sc}^2 = \frac{1}{4} \pi \times P_t / P_j \times G \sigma / B.$$

We find that R_{sc} equals 15 nm (assuming B equals 0.5 mc).

Our computation gives merely an order of magnitude for the effect of distance on received signal and jammer power. A more accurate formula would take into account the actual S/N required for detection and therefore the number of pulses integrated in a beamwidth (the jamming adds incoherently) and the variation of antenna gain with elevation. Furthermore P and σ are not independent: in practice, a larger vehicle puts out more jamming power.

We can see that the first job of the jammer is to find the radar frequency and jam on this frequency. Conversely, the radar must avoid the jammer's frequency. A good anti-jamming radar above all must be able to shift frequency quickly and, if possible, over a wide band.

The ultimate in anti-jamming is reached when the frequency is changed on each pulse in a random manner. With the fastest possible reaction time, a narrow-band, or "spot", jammer can then only jam the receiver from the instant the radar pulse is received to the end of the pulse interval. The problem is further compli-

cated for the jamming vehicle because it probably must jam several radars at once. The only solution is to use wideband jamming and accept the resulting power dilution.

Spot jamming, we have seen, is no good against radars with frequency "agility". However, there are older radars that don't have this agility, and there is also deception jamming, which the radar may not even realize is going on. In these cases, some form of counter-measures must be used against spot jamming.

Figure 1 shows that narrow-band jamming can be CW, pulse, or noise. Normally the output of the radar receiver consists of target returns competing with front-end noise (if we neglect interference due to clutter or weather). The target returns have certain predictable characteristics, like pulse length and, for a group of target pulses, beamwidth.

Theoretically, the receiving and processing circuitry can filter out signals that do not show the expected target characteristics. For instance, each received pulse that exceeds a certain threshold can be stored before display for the duration of one sweep and compared with the same range increment on the next sweep. If the pulse turns out to be isolated (i.e., random), it can be blanked out, so that it will not reach the display. Long pulses can be differentiated in a short-time-constant circuit and reduced to short pulses.

This theory for the elimination of random pulse jamming (which also covers accidental interference, as from another radar), holds true only at low repetition rates. If the rep rate is high compared with the PRF of the radar, the blanked periods may become too long and targets will be suppressed.

Special circuits help against jam

Combatting CW jamming is mainly a question of avoiding receiver saturation by using special circuits (of which IAGC is a classical example). If saturation can be avoided, the dc component of the detected output can be removed by a fast-time-constant circuit and the beat between wanted signal and CW jamming can be detected by a third detector rectifying the video. However, since the AGC action will reduce the gain in proportion to the jamming, both noise and target will be reduced in amplitude unless there is a corresponding automatic increase in video gain. The whole procedure still offers only a poor alternative to a shift in frequency, especially since fast-time-constant circuits can be foiled by modulated CW.

Deception jamming, usually in the form of pulse repeater jamming, consists of re-transmitting the radar pulse received by the jammer after a suitable delay and gating the transmission for a time corresponding to the beamwidth of the radar antenna. From the point of view of the radar, the received jamming looks exactly like a target, especially since it can be programed to have realistic motion.

Certain problems are associated with this form of jamming. The RF pulse, for one thing, cannot be delayed by more than a few microseconds at the present state of art. If there is any further delay, the pulse first must be converted to video and the delayed video signal used to modulate the transmitter.

If the jamming signal happens to be narrow-band, finding the correct frequency is a problem. One solution is to transmit a wide-band signal, such as a burst of wide-band noise. If the radar transmitter PRF is jittered,

then the false target can only be generated at a range greater than the jammer range—if the pulses are delayed until they appear on the next sweep, they will not be correlated in range and therefore can be eliminated by the receiver as random.

If the radar doesn't shift frequency on a pulse-to-pulse basis, it may be jammed by a deception jammer and never know it, especially if the jammer is generating realistic tracks. The only solutions in such a case are frequent and radical frequency changes irrespective of the jamming situation or picture correlation with another radar.

Narrow-band jamming uses CW modulated by noise. Usually, the depth of modulation is such that there is a considerable amount of CW. The noise jamming cannot be eliminated, but anti-CW measures will help. Against all other forms of narrow-band jamming, a shift in frequency is the only really effective counter-measure.

Operator or complex gear needed

Narrow-band jamming requires an ECM operator or fairly complex equipment to determine the frequency of the radar and to track it when it shifts. In addition, there must be as many jamming circuits as there are radars to jam. For a given equipment weight and minimum complexity, therefore, a wide-band jammer appears to be best.

Wide bandwidth may be obtained by transmitting very short pulses, by sweeping a "narrow-band" jammer over a band of frequencies, or by amplifying wide-band noise in a wide-band traveling-wave-tube transmitter. The very-short-pulse method is hardly wideband enough to be included in this list, yet it is definitely out of the narrow-band category. A short pulse in the receiver passband has enough energy to make it ring for an appreciable period—on the order of the radar pulse length (τ). If the PRF of the jamming pulse is on the order of $1/\tau$, then the receiver is continually jammed.

This technique requires a high-powered jamming pulse. The receiver can cut down on its effect by limiting at some value greater than the maximum useful target signal. For maximum efficiency, the limiting should take place at a point in the receiver at which the bandwidth is on the same order as the jamming pulse—limiting should take place after a wide-bandwidth front end.

The simplest way to wide-band-jam is to sweep a narrow spectrum across the band. If the sweep rate is low, the effect is similar to that of random-pulse jamming. If the frequency is high, with the sweep rate greater than $1/\tau$, the problem is similar to that posed by very narrow pulses. If the sweep rate is random (as for a carcinotron modulated by noise), the effect is the same as that of wide-band noise.

Faced with a wide-band noise jammer, the radar cannot use frequency shift tactics. Since the jamming looks like receiver noise, there is nothing, once the optimum bandwidth has been reached in the receiver, that AJ circuitry can do short of trying to "burn through" by increasing the time that the radar looks in any particular direction and integrating. The best solution, therefore, is to detect at least those targets that are stronger than the noise and avoid overloading by false targets generated by random noise pulses. It can be achieved by some form of noise AGC that operates on the false-alarm count and keeps it constant.

The radar can also discriminate against the jammer on the basis of azimuth. However, the 30 db or so available from the antenna's directional characteristics may not be enough, particularly if the sidelobe level is only 15 dbn down.

Decoys and chaff jam passively

As *Figure 1* shows in the table, the two forms of passive jamming in current use are decoys and chaff. The most realistic decoys are small, aircraft-type vehicles that can be carried and launched by conventional bombers. They can be fitted with corner reflectors or other radar enhancement devices to give them a radar cross-section comparable to that of a much larger aircraft. In a tactical situation, these decoys would be launched by attackers outside the normal radar detection ranges to cause dispersion and overloading of the defenses when the real raid takes place.

Decoy discrimination is difficult, although it might be done on the basis of reflection characteristics or size. Since a decoy might conceivably carry a bomb, the best policy possible would be to destroy all unfriendly targets, including known decoys.

Chaff at present is used in spot and corridor forms. The spot variety consists of small bundles of strips of metallic foil that are released intermittently. Until scattered by the wind, these bundles look like normal targets and overload the defense systems. Soon after release, though, they lose the forward motion imparted to them by the carrying vehicle and drift with the wind while falling. Because of this drift, moving-target circuitry can spot them for what they really are. Even without MTI, a competent operator should be able to recognize them.

The theory behind corridor chaff is that the lead planes in an attack can, by continuously releasing chaff, produce a long cloud, or corridor, through which the following aircraft can fly undetected. In practice, this technique has two drawbacks:

- The corridor pinpoints the releasing aircraft.
- It is very difficult to coordinate a long range attack so that the second wave of aircraft is sure to fly down the corridor before the chaff has been dispersed.

Ground DFs can spot ECM aircraft

Passive systems can be used for ECCM as well as ECM. Passive direction finders can pick up radiations from a jamming vehicle for triangulation by two or more ground receiving stations.

However, this approach is not as easy as it may first seem. When there are more than three or four jamming aircraft, passive DFs can become confused by the number of intersections of cross-bearings—some of which locate real targets while others locate only "ghosts" (*Fig. 2*). The ghosts increase in number as the square of the number of jammers, and they can be quite hard to get rid of. "Ghost" discrimination is helped by narrow beamwidths on the DFs, discriminating in elevations, and good data links between the triangulating stations (for passing on such correlation information as type of jamming).

The ground defenses can also use decoy transmitters to foil airborne countermeasures. These simple and cheap sets might look like a full radar station to an attacking vehicle and induce it to waste some of its limited power as it jams over a wide band of frequencies.—End

4

Counter-countermeasures: good design can beat the ECM threat

- Ground defense radars have clear advantage
- ECCM has led to broadening of frequency range
- Radar operator is important ECCM "device"

by **Murray Simpson,**

Assistant Vice President
and Technical Director, The W. L. Maxson Corp.*

IN ITS EARLIEST and most basic form, radar countermeasures equipment was designed primarily to obliterate the radar echo by increasing the receiver noise level until the radar return was no longer visible. This effect is readily achieved by generating a CW noise-modulated signal strong enough so that it arrives at the radar receiving antenna at a level higher than that of the "skin echo" from the target. The ECM transmitter has a power advantage, because the radar operates on a two-way basis—the received power is in inverse proportion to the fourth power of range (in accordance with the radar equation), while the power received at the radar from the ECM transmitter is inversely proportional to the square of range (in accordance with the beacon equation). This makes it practical to use relatively moderate ECM transmitter powers against high power radar systems.

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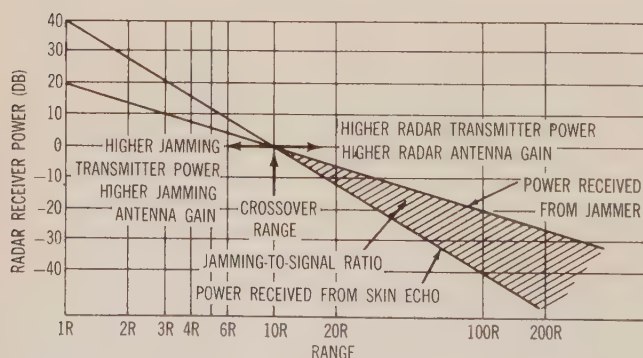


FIGURE 1: Radar-received power varies as $1/R^4$ for the skin echo and $1/R^2$ for the jamming signal. As the jammer moves in, the ratio of jamming power to signal power (J/S) is seen as the receiver decreases. If a radar cannot pick out a signal below the noise level, it can detect the approaching target only when J/S is less than 1 (i.e., after the crossover point). If the effective radiated jamming power is increased, the carrying vehicle is screened from detection at a closer range. Likewise the detection range of the radar is increased if the radar's radiated power is increased.

In addition to the noise jammer, many other types of ECM have been used that depend on various methods of confusing the radar operator. In general, these types have one thing in common: they do not attempt to saturate the radar receiver on a CW basis. Rather they provide signals similar to the normal skin echo return from the target but displaced in so as to make it extremely difficult or even impossible for the radar operator to distinguish the true target from the false signals.

Such systems have many important advantages. For one thing they can operate with relatively low-powered ECM transmitters. In certain cases, it is impossible for the radar operator to know that he is being deceived.

To find the amount of ECM power required for effective jamming, we first must know the power returned to the radar from its own signal. This is given by the well-known equation:

(1)
$$P_{rr} = P_{tr} G_r^2 \sigma \lambda^2 / (4\pi)^3 R^4,$$
where P_{rr} is power at radar receiver from skin echo; P_{tr} , power of radar transmitter; G_r , radar antenna gain; σ , target cross-section; λ , wavelength; and R , range.

This equation shows that the received power is inversely proportional to the fourth power of range. The power received from the ECM transmitter is given by the beacon, or one-way transmission, equation:

(2)
$$P_{rj} = P_{tj} G_r G_j \lambda^2 / (4\pi R)^2,$$
where P_{tj} is the power of the jamming transmitter; G_j , jammer antenna gain; and P_{rj} , power at the radar receiver from the jammer.

Greater range lowers power needs

We can see from Equation 2 that the power received at the radar from the jammer is inversely proportional to the square of the range. To find the amount of ECM transmitter power needed to drown out the radar skin echo return, you simply divide Equation 2 by Equation 1 and introduce the proper jamming-to-signal ratio (P_{rj}/P_{rr}):

(3)
$$P_{tj} = P_{rj}/P_{rr} \times P_{tr} G_r \sigma / 4\pi R^2 G_j,$$

Some very interesting conclusions can be drawn from Equation 3. Most important is that we now see that the amount of required ECM transmitter power is *inversely proportional to range squared*. So the greater the range of the target from the radar, the less ECM transmitter power is required for effective jamming. This is the opposite of normal communications and radar practice. Moreover, at some range the signal received from the jammer at the radar receiver falls below the level necessary for establishing the minimum jamming-to-signal ratio. Short of this so-called "cross-over" range, satisfactory jamming is impossible.

An important principle in ECM design is to make sure that the cross-over range provided by a particular design meets the tactical requirements. For example, assume an aircraft carrying a jammer must penetrate a radar defense system. The cross-over range for that particular jammer in operation against the radars of the defense net is 30 miles, and the ground defenses can shoot down the aircraft up to 15 miles range. The vulnerability of the aircraft is extremely high. The airborne jammer will not protect the aircraft on this mission.

Figure 1 shows the power received at the radar receiver from the jammer and the radar skin echo as a

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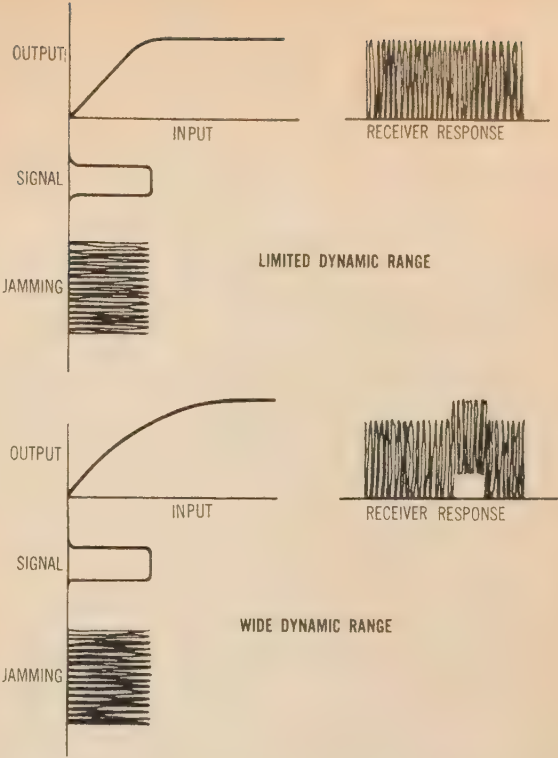


FIGURE 2: Effects of receiver saturation under jamming conditions.

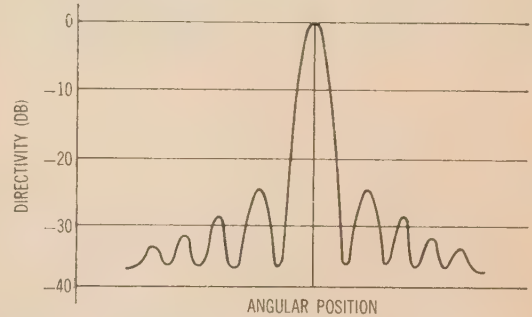


FIGURE 3: Typical radar antenna pattern.

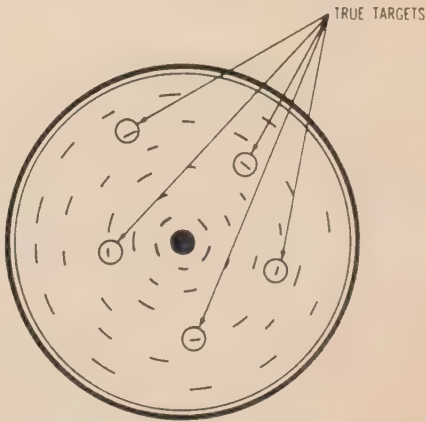
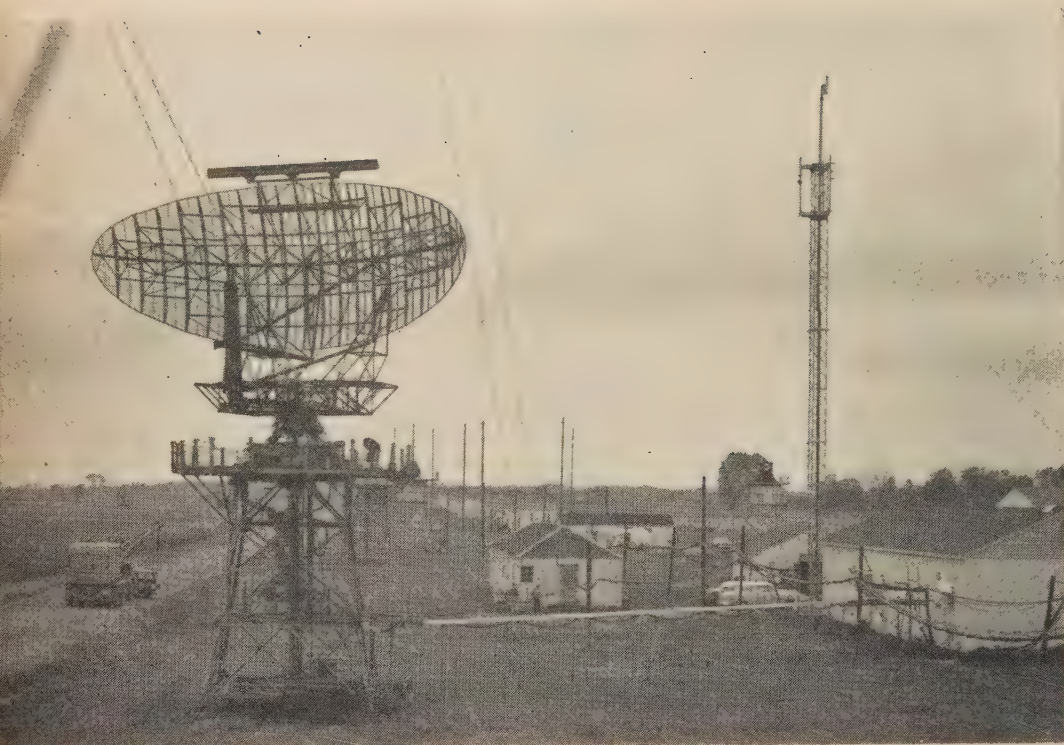


FIGURE 4: Multiple target generation as it appears on PPI.



ECM TEST facility at Rome Air Development Center has 20 different types of radars covering the entire usable radar spectrum. Included are the FPS-20 (foreground) and a number of duplicates of Russian radars. The facility primarily evaluates new ECM systems, components, and techniques.

function of units of range. The cross-over range is clearly seen where the two curves cross.

Noise jamming, as we've noted, has always been a basic form of ECM. It is extremely attractive because of its fundamental nature—it is identical to the normal receiver noise which always exists in a radar system. Therefore it cannot be distinguished from receiver noise and makes the counter-countermeasures problem extremely difficult.

Early radar receivers easy to jam

The limited dynamic range of early radar receivers made them extremely vulnerable to jamming. Against these receivers, the jamming signal could even be weaker than the skin echo. So long as it exceeded the receiver's dynamic range it would drive the receiver into saturation. Once saturation has occurred, no additional amount of input signal power would make the input signal detectable.

Figure 2 shows the effect of the response of a limited-dynamic-range receiver to a jamming signal equal to the skin echo response. The saturation in the receiver shrouds any information from the skin echo. Figure 2 also shows a receiver with a wider dynamic range with similar values of skin echo and jamming signal. In this case, the skin echo is definitely visible.

Directional information is obtained in a radar system from a highly directional antenna. When a signal is received it is assumed that the direction of the target corresponds uniquely to the direction of the radar antenna beam.

Ideally, the radar antenna should not have any side-

lobes, so that there will be no reception from directions other than that of the main beam. We know, however, that sidelobes can't be avoided. Figure 3 shows a typical radar antenna pattern in one plane.

We can see from Equation 1 that the normal radar signal is proportional to the square of the antenna gain. Since the sidelobes for a reasonably well-designed antenna are at least —20 db or lower, it is unlikely that the normal skin echo return, except for extremely close targets, will be picked up by the sidelobes. However, in a jamming situation, Equation 2 shows, that power received by the radar is directly proportional to the radar antenna gain. Under these conditions, it is therefore definitely feasible for jamming signals to enter the sidelobes, provided the jammer power is 20 db or higher than the normal radar skin echo. In many cases, this jamming technique can be used quite effectively, since it destroys information over a very large azimuth on the radar PPI scope.

False targets produced to deceive

Another important form of jamming, designed primarily to confuse, generates a large number of false targets with characteristics very close to those of the actual target. When picked up by the radar, these false targets appear in various azimuth and range positions along with the true target, making it difficult, if not impossible, for the radar operator to tell for sure which is the right blip.

The multiple-target technique likewise takes advantage of radar antenna sidelobe imperfections. The jammer transmits many pulses per radar pulse period, and

these pulses are made strong enough to enter the antenna's sidelobes. This effect is shown in figure four. Many degrees of sophistication can be added to this basic technique to maximize the confusion.

Chaff has been used since the earliest days of ECM to produce large numbers of false targets. It is still a very important form of ECM.

Since ECM has become a more or less standard technique in military operations, radar system designers are forced to consider the operation of their system in a countermeasures environment. To cope with this environment, several electronic counter-countermeasures (ECCM) techniques have been evolved.

Just as the ECM designer must understand details of the operation of the various radar systems that he must operate against, so must the radar ECCM designer understand the various forms of ECM that his radar system is likely to encounter under tactical conditions. He must be prepared to operate his radar against several forms of ECM, since he cannot know in advance what particular technique may be used against him.

ECCM looks impossible at first

At first glance, it may seem that this task is impossible. However, further analysis shows that this is far from being the case. Indeed, in many areas of electronic warfare, radar has a very definite advantage. This is particularly true in the case of ground defense radar systems operating against airborne jammers. The ground radar usually is a high power unit of substantial size, whereas the airborne jammer must necessarily be limited in size and power capability and, at the same time, must be extremely versatile in frequency and modulation characteristics.

Radars have been designed in various parts of the frequency spectrum, ranging from VHF to very high microwaves. In the early days, specific frequency bands were assigned to certain types of radar. In many cases, these bands were relatively narrow and the radars were usually fixed-tuned to a particular frequency. This obviously made the ECM job relatively simple, since the ECM transmitter had to cover only the frequency bands of the operating radars.

As the importance of ECCM became better understood, a strong trend toward broadening the frequency range developed. New radar systems were designed to operate over a much wider part of the spectrum. Jammers were then forced to follow suit. They now had to cover the entire potential radar frequency band if they were to be effective. Moreover, if the radar is continuously monitoring the jamming signals, it can readily pick holes in the jamming spectrum and be shifted to a clear channel (Fig. 5). Using available state-of-the-art components and techniques, the designer can make this frequency shift quite rapid and even automatic. Today rapid tunability is one of the strongest ECCM design tools.

We have seen that a receiver with a limited dynamic range makes a radar system very susceptible to noise jamming, even though the radar may operate reasonably well in a non-ECM environment. Obviously extending the receiver's dynamic range is a very useful radar ECCM technique. It makes it possible to observe

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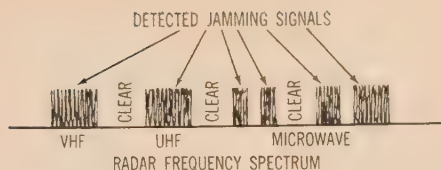


FIGURE 5: Continuous scanning of the spectrum is mandatory to enable the radar to choose clear channels within its operating frequency range.

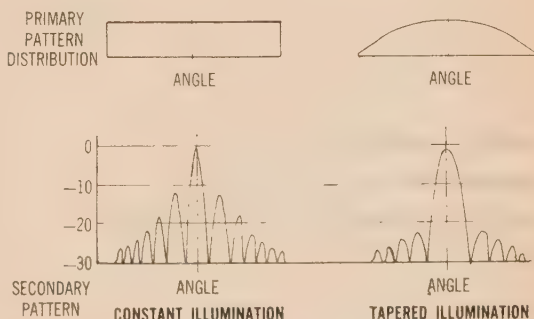


FIGURE 6: Variation in radar antenna beamwidth and sidelobe level resulting from the primary pattern distribution.

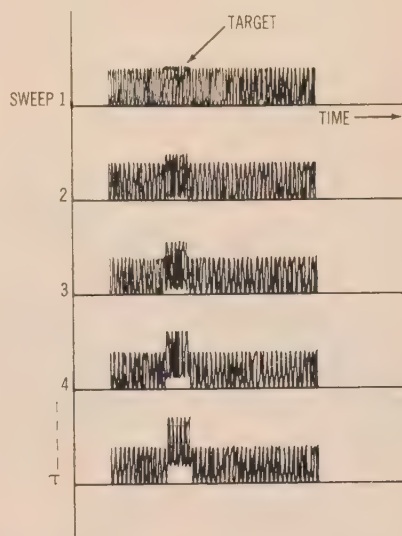


FIGURE 7: Improvement of signal detection as a result of linear integration of τ sweeps.

the radar skin echo even when it equals or is less than the jamming signal (*Fig. 2*). Radar receiver dynamic range may be increased by many techniques, like logarithmic receiver response and other non-linear receiver characteristics.

The most direct counter to sidelobe jamming is to improve the radar antenna and reduce the sidelobe levels. This technique cannot be depended upon completely, because of the physical limitations of radar design. The maximum gain of the radar antenna is obtained when the antenna is illuminated uniformly by the primary feed. However, in such a design, the first sidelobe is only 13 db down, in accordance with the $\sin x/x$ distribution (*Fig. 6*). A lower sidelobe level is obtained by a tapered distribution using a cosine or cosine-squared function. This approach cuts the sidelobe level to -20 db or less, but also broadens the main beam and decreases the antenna gain (*Fig. 6*). This tradeoff rapidly approaches a limit beyond which it is no longer practical to taper the illumination in return for reduced antenna gain.

Signal detectability is improved

As we have seen, one of the most common forms of jamming uses noise modulation. This has the effect of increasing the noise output of the receiver. Therefore, an obvious counter-countermeasure would be to improve signal detectability in the presence of noise. Needless to say, this technique is important even in the absence of jamming as a means for extending normal radar

range. When there is ECM, it becomes an absolute necessity if you want to preserve standard radar performance.

The basic technique used to recover a radar signal in noise relies on the fact that the desired signal is video-coherent—it occurs on every radar pulse at the same point on the time scale for a fixed target. Noise, on the other hand, is fluctuating and non-coherent.

Figure 7 shows the appearance of signal and noise on successive radar sweeps. In a single sweep, the radar receiver can't possibly determine the difference between the signal and noise, if the two are comparable in value. However, if many looks are stored and linearly integrated, the video signal return will add on successive sweeps in a direct manner, while the noise will add in an RMS fashion. With integration, you can therefore "extract" the signal from the noise, provided the integration time is long enough.

The price paid for the signal-to-noise enhancement is time. The signal sensing circuits must dwell on a target for some time (the integration period) before the target can be reported.

Various sophisticated techniques for achieving this effect involve the use of correlation functions. If the integration period is long enough and the target does not change its characteristics in that period, very substantial improvements in signal detectability in noise can be achieved.

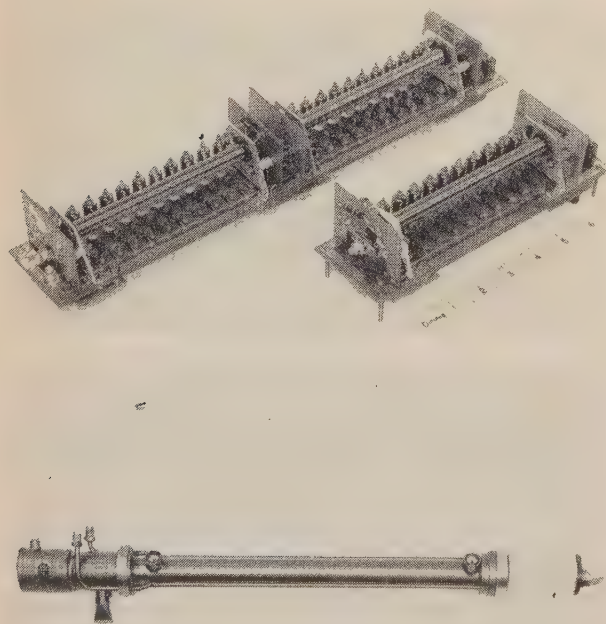
Figures 1 & 3 show that the required jamming power is directly proportional to the radar transmitter power for a fixed jamming-to-signal ratio. As the radar transmitter power is increased, the cross-over range moves out, making the target substantially more vulnerable. So the development of larger power radar transmitters greatly improves the ECCM capability of the radar.

Large antennas for most future radars

Very large antennas, too, are practical on the ground. In fact, most future ground radars will use large antennas to get higher resolution and gain. As *Equation 3* shows, high gain also improves the ECCM capability of a radar. If gain is increased, the jammer must correspondingly increase his power if he wants to maintain his effectiveness. Since pencil-beam antennas have substantially larger gains than fan-beam types, they also have considerably greater ECCM capability for a given radiating area.

One particularly important ECCM "device" is the radar operator. Because of the tremendous impact of ECM on radar performance, today's operator must be thoroughly trained to recognize all possible forms of ECM and their effects on his particular radar. Above all, he must avoid the confusion which usually is the prime objective of ECM.

In view of the many new requirements heaped on the radar operator, a new occupational specialty should be created—the electronic warfare specialist. His prime function would be to understand and use ECCM techniques in the presence of jamming. Since these techniques are, in many cases, sophisticated and very specialized, he may often operate independently of the normal radar operator. His principal duty would be to make the information presented to the radar operator sufficiently accurate and clear so that the radar operator can perform his normal duties.—End



SPERRY AMPLIFIERS for automatic jamming. Distributed-amplifier units (top) serve as wide-band receiver amplifiers for the low frequency channels; 200-W X-band traveling-wave tube (bottom) is typical of the power amplifiers used to transmit jamming signals. This tube is less than 28 in. in length, weighs 11 lb, and provides 40 db minimum gain.

ECM data file

IN DESIGNING electronic countermeasures, radar, and line-of-sight communications systems, figuring the system parameter tradeoffs often is a tedious mathematical process. These *Nomographs* make the operation simple and easy. Three of them solve the one-way, two-way, and self-screening range transmission equations. The fourth *Nomograph* helps you find the jamming-to-signal power ratio.

The one-way equation solves for the received jamming power (J) and the required receiver sensitivity:

$$J = K_1 \{ (P_r G_r G_i \lambda^2 \sigma) / [(4\pi)^2 R_i^4] \} (B_r / B_i).$$

The two-way equation gives you the jamming power needed to prevent detection of the radar echo. In the absence of jamming, you can also use it to find the detection range of your radar, provided you know the minimum detectable signal (S_{min}).*

This equation can be expressed as:

$$S = K_2 (P_r G_r^2 \lambda^2 \sigma) / [(4\pi)^2 R_i^4],$$

where S is the signal power returned to the terminals of the transmitting antenna by the target reflection.

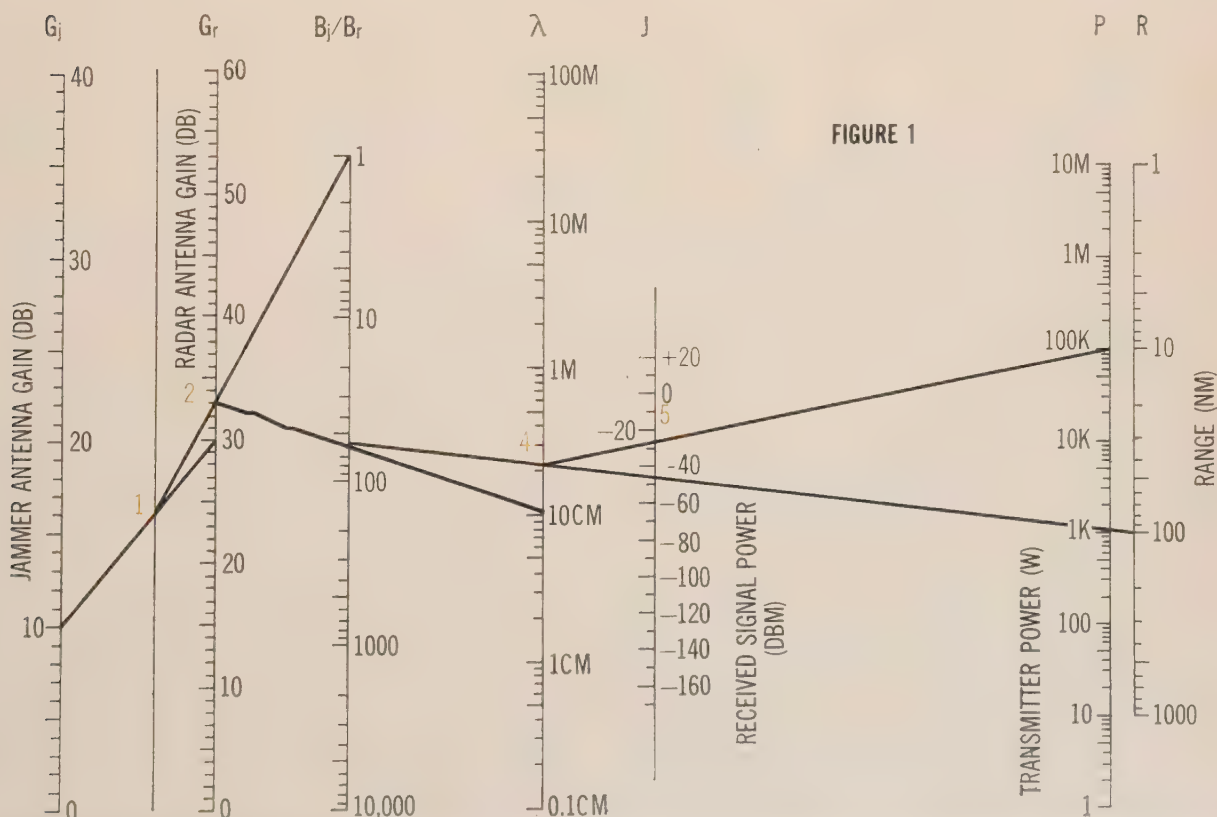
The self-screening range equation can be expressed as:

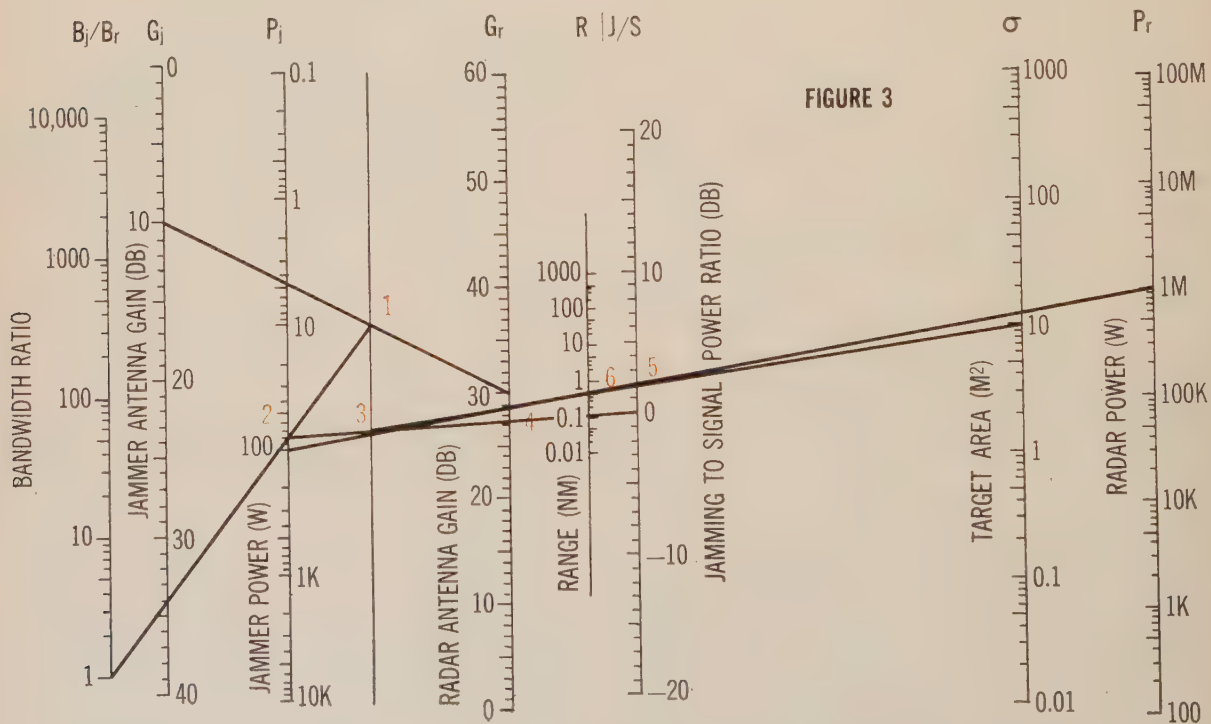
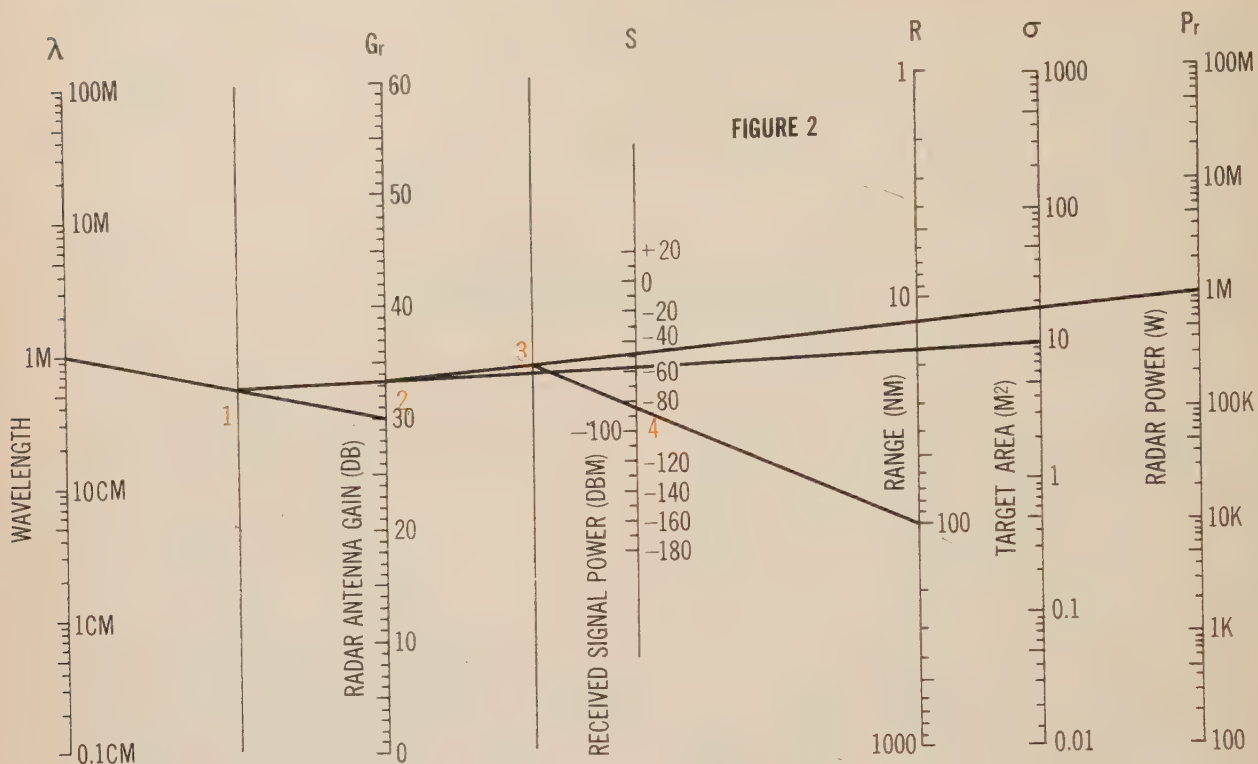
$$R = K_3 \sqrt{[(\sigma P_r G_r) / (4\pi P_i G_i)] \times (B_i / B_r) \times (J / S)},$$

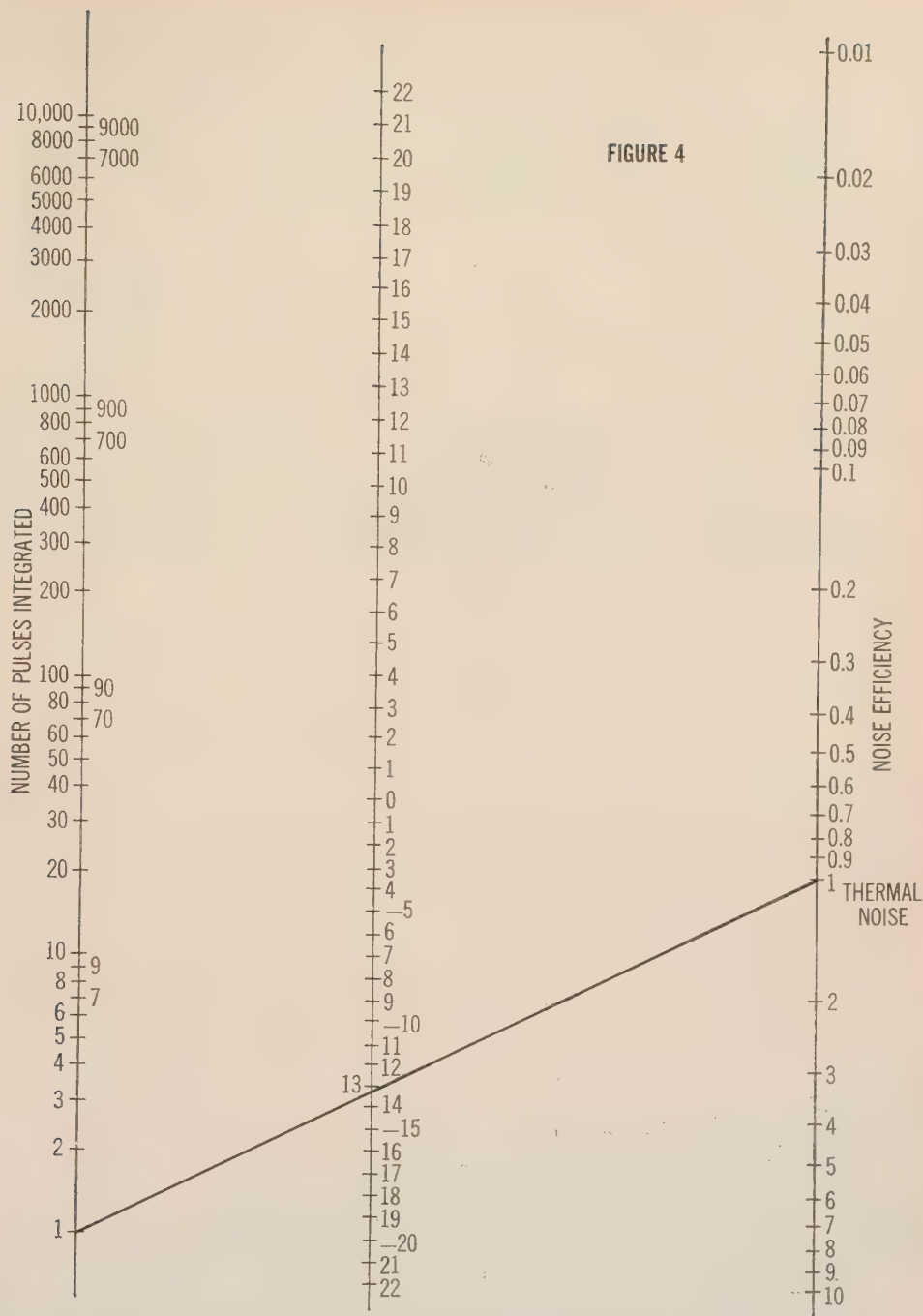
where R is the maximum detection range of the radar in a noise-jamming environment; B_i / B_r , the ratio of transmitted spectrum to receiver bandwidth; and J / S , the ratio of jamming power to signal power required at

* For search radars, S_{min} (in dbm) equals the noise figure (in decibels) plus 10 log (receiver bandwidth in cps) minus 5 log (hits per scan) minus 163.5; for tracking radars, it equals the noise figure (in decibels) plus 10 log (receiver bandwidth in cps) minus 3.33 log (PRF in cps) minus 163.5

more on next page







the radar receiver to produce any jamming effect.

How you use the *Nomographs* is shown by the sample problems, whose step sequence is indicated by the colored numerals:

• *One-Way Transmission (Fig. 1)*—Enter $G_j = 10$ db, $G_r = 30$ db, $B_j/B_r = 1$, $\lambda = 10$ cm, $R = 100$ nm, and $P = 100$ kw. The result, as shown at Intersection 5, should be $J = -28$ dbm.

• *Two-Way Transmission (Fig. 2)*—Enter $\lambda = 1$ m, $G_r = 30$ db, $\sigma = 10$ m², $P_r = 1$ Mw, and $R = 100$ nm. The results, as shown by Intersection 4, should be $S = -83$ dbm.

• *Self-Screening Range (Fig. 3)*—Enter $G_j = 10$ db, $G_r = 30$ db, $B_j/B_r = 1$, $J/S = 0$ db, $\sigma = 10$ m²,

$P_r = 1$ Mw, and $P_j = 100$ W. (For B_j/B_r , use a value of 1 even if the true value is larger.) The result, as shown by Intersection 6, should be $R = 0.52$ nm. To find the self-screening range, J/S must be known accurately. If it isn't known, you can use the *Nomograph in Figure 4* to find it.

• *J/S Ratio (Fig. 4)*—This nomograph assumes a detection probability of 50 per cent and a false-alarm-rate probability of 10^{-10} . Enter 1 as the number of pulses integrated and 1 as the noise efficiency. The result should be $J/S = -13$ dbm.—End

These nomographs were prepared for SPACE/AERONAUTICS by the Advanced ECM Engineering Section, Advanced Electronics Center, Light Military Electronics Dept., General Electric Co., Ithaca, N.Y.

GPL combined guidance

A.I.D. Navigation Systems

Combining state-of-the-art equipment in several fields to create new and superior systems for aircraft and missile guidance is still another GPL capability. One case in point is GPL's Astro-Inertial-Doppler A.I.D. navigation system—a stellar monitored, doppler tuned and damped inertial system—in which each element refines the others, and the system as a whole provides far greater inherent accuracies.

A.I.D. and other combined guidance and integrated systems now under development at GPL are particularly significant because they utilize *existing* systems and elements, *existing* components of proven reliability and accuracy, *existing* techniques for manufacture and maintenance. Yet continuing study of progress in the state of the art and continuing study of new system concepts keep these systems as advanced as the aircraft and missiles they will guide.

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Vast new scale for countermeasures in space

- Early space ECM will depend on "auntie"
- Ground radars to be easier to jam
- New uses for infrared and optics

IN THE opinion of most electronic-warfare experts, electronic countermeasures will expand along with space flight. Just which ECM techniques will be used in space and what specific role they will play—especially during the next, exploratory decade—depends on the design and mission of the coming space vehicles.

A brief look at some of the military extra-atmospheric vehicles already in development can give us an idea about what spatial ECM will be like. First came the IRBMs, fired along ballistic trajectories over ranges of about 1500 miles. A short time later came the ICBMs, fired along similar trajectories over ranges of 5000 miles and more.

The first true spacecraft for military purposes probably will be the recon and surveillance satellite (chiefly designed around ballistic missile hardware). It is expected to become operational about 1962-65. Its operating altitude will be between 200 and 1000 nm, its velocity about four nm/sec, and its payload 0.5-1 ton.

What comes after 1965? A rocket-launched boost-glide vehicle has been predicted, either manned or unmanned, that would have a range of over 5000 nm and fly at relatively low altitude and velocities ranging from conventional landing speed up to several miles per second. If successful, it should lead to a still more advanced type: a high-endurance manned satellite or orbital bomber.

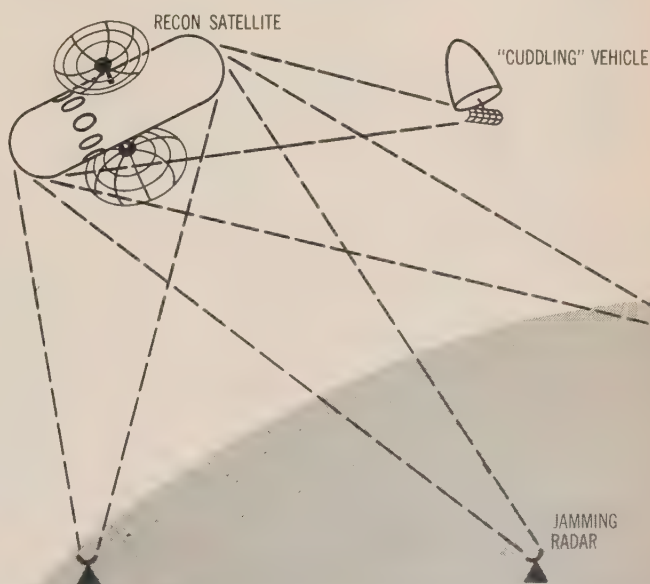
Effective ground-based defenses against space vehicles do not exist today. Exactly what must be developed depends, of course, on the performance to be expected from the spacecraft themselves. If you consider altitude and speed alone, says Forrest Cooper, Jr., manager of ECM engineering at GE's Light Military Electronics

Department, the ECM figures for manned bombers or air-breathing vehicles in general would have to be increased about 10 times.

Cooper points out, for instance, that defense system engineers claim early-warning and surveillance radars in an anti-spacecraft defense network must have maximum detection ranges an order of magnitude greater than those of comparable radars for defense against manned aircraft. The overall gain of a radar system is proportional to the fourth power of the range capability, so you need the radar receiver to produce only jam-

more on next page

FIGURE 1: The problem of the electronic recon satellite in the next decade will be to overcome ground-based ECM. Here a recon satellite is jammed from ground radars and a jammer-carrying "cuddling" vehicle fired into orbit.

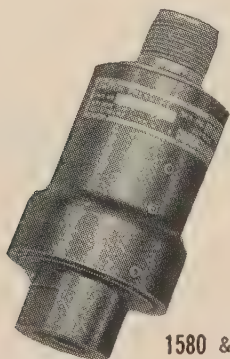


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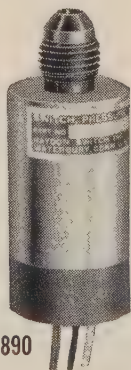


1580 & 1880

The 1580 *Miniature Gage Pressure Switch* (4 ounces maximum, 3" x 1½") and the 1880 *Miniature Absolute Pressure Switch* (4 ounces maximum, 3¼" x 1½") have SPDT or DPDT circuitry, with either sealed or unsealed snap-action switches. Operating pressure range: 0.5 psi to 3,000 psi.



1590



1890

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Switch INCORPORATED

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(6 ounces, 3⅞" x 1⅝")

2¼" x 0.875") have SPDT circuitry with sealed or unsealed snap-action switches. Operating pressure range: 10 psi to 3,000 psi.

GENERAL DESIGN SPECIFICATIONS APPLICABLE TO ONE OR MORE OF THE ABOVE VERSIONS.

Sensing elements: A wide variety of diaphragm or piston sensing elements can be provided in each of the configurations. Thus, a standard design is easily tailored to specific pressure settings and environmental conditions. Pressure switches are available with welded metal sensing elements when corrosive media or extreme temperatures dictate all metal construction.

Operating media: Ammonia systems, freon, lubricating and hydraulic oils, aircraft fuels, radioactive water, oxidizers.

Environmental: Switches meet applicable portions of MIL-E-5272, high and low temperature, shock and vibration:

Standard temperatures:

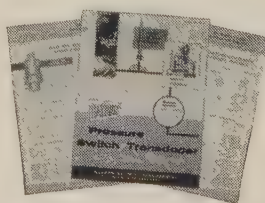
-65° to 250°F.

Vibration: 10g.

Special designs made to 600°F. and vibration to 20g.

Electrical: Snap-action switches meet MIL-S-6743. 5 amp. res./3 amp. ind. at 30v DC/125v AC.

Higher electrical loads available: 10 amp. res./8 amp. ind.



ECM IN SPACE . . .

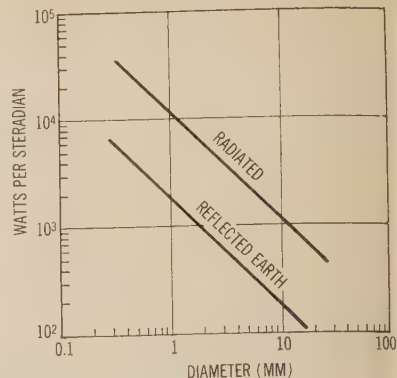


FIGURE 2: Radiated energy from a cluster of ferrous particles weighing 10 tons. The temperature of this mass is 20 deg C; reflectivity and emissivity are 0.5.

a ten-thousand-fold increase in system gain for a tenfold increase in range. The same reasoning holds for local-defense tracking systems, whose accuracy must also be increased to provide a reasonable intercept probability for defensive missiles.

Naturally the picture is not all black—some spacecraft characteristics are a boon to ground defense. For one thing, spacecraft follow predictable flight paths. In the case of ICBMs, the flight path can be calculated pretty accurately, if you know the location of the launching sites and also the potential targets. Similarly you can determine the orbit of a recon satellite or an orbital bomber and predict the future whereabouts of such a vehicle fairly far ahead.

True spacecraft, which operate entirely outside the atmosphere, lack the maneuverability of aerodynamic vehicles. Boost-glide vehicles operating on the fringes of the atmosphere (i.e., at the highest possible altitudes at which aerodynamic lift can be obtained), can have a measure of maneuverability, but naturally only if they sacrifice altitude. In either case, the defense gains.

Re-entry requirements may also help the defense, mainly in two ways:

- If a gradual descent to the earth is necessary in the case of a manned boost-glide vehicle, the vehicle could be kept under surveillance from the ground for a long time at relatively close range.

- Increased radar reflectivity, a persistent and readily detectable anomaly, may be caused by ioniza-

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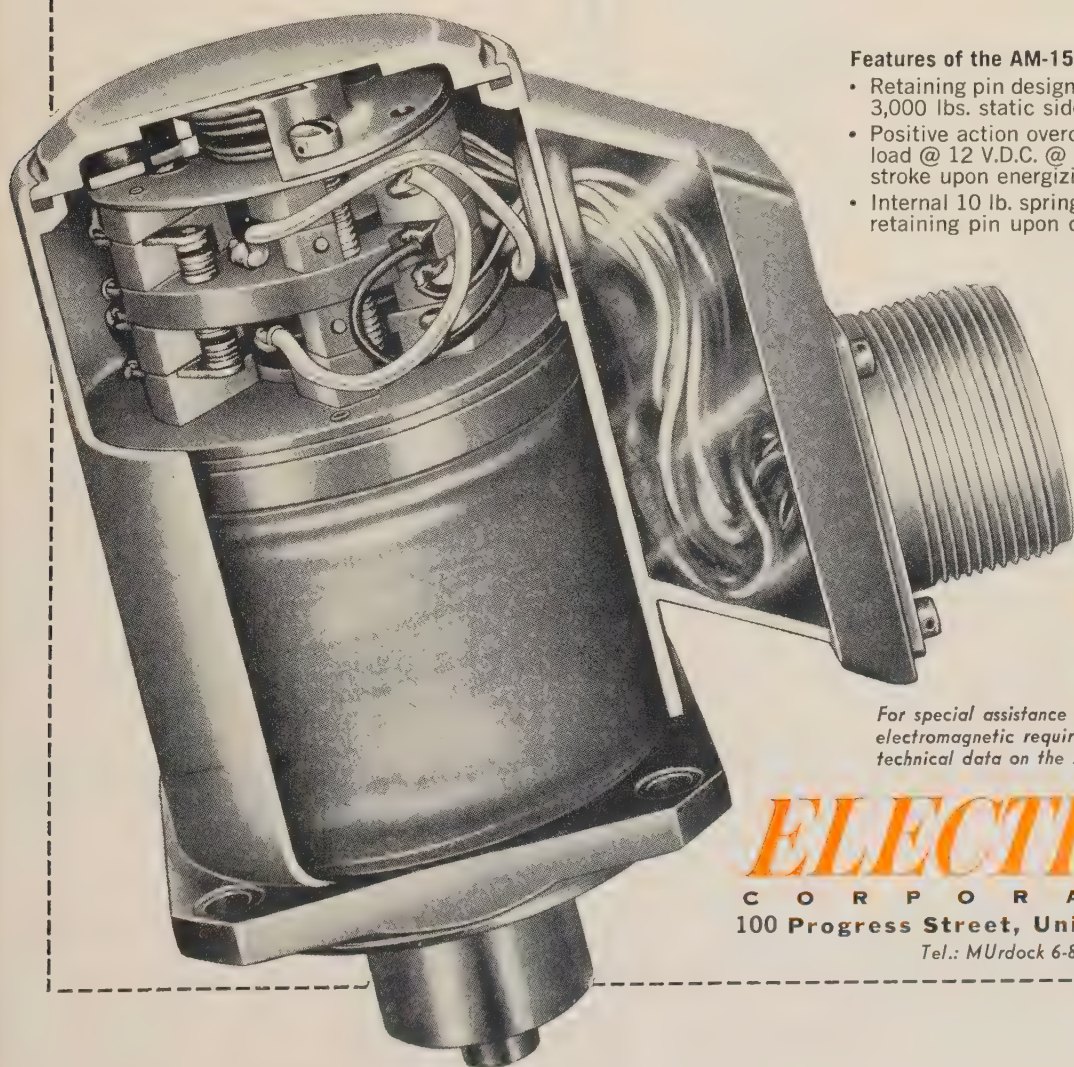
SPACE/AERONAUTICS

Unique Electromechanical Interlock Performs Multiple Switching and Signalling Functions...

Fail-Safe Feature: Retaining pin design withstands 3,000 lbs. static side force

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This feature, by either internal or external electrical connection of the switches, can be made to interlock remote mechanical or electrical action. Provides high shock and vibration resistance (meets MIL-S-7029, MIL-E-5272 and MIL-S-4040 specifications). Fail-safe feature for aircraft, missiles and missile launchers.



Features of the AM-1500 (as illustrated)

- Retaining pin design withstands 3,000 lbs. static side force.
- Positive action overcomes 15 lbs. load @ 12 V.D.C. @ 72° F @ .250 stroke upon energizing.
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For special assistance with your particular electromagnetic requirements and for complete technical data on the AM-1500, write today.

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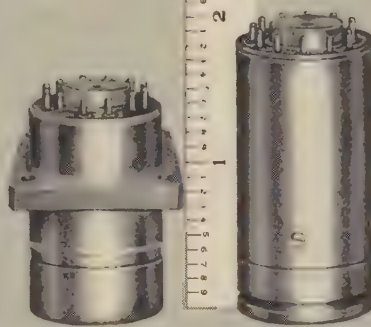
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A STATEMENT FROM FAIRCHILD ON SUB-MINIATURE RATE GYROS

Fairchild hasn't cornered the market on rate gyros. Other leading firms are also building them... But no one but Fairchild is building them as small, as rugged, as precisely and with so many exclusive features.

Fairchild's rate gyros are the smallest made. Type RG-101 is 15/16" diam. (exclusive of mounting flange) x 1 1/8" long, weighs less than two ounces. Model RG-100 is slightly larger.



RG-101

RG-100

FAIRCHILD Rate Gyros Are So Rugged!—Take 150 g's of shock, and 30 g's to 2000 cps vibration, even at rates as low as 10° per second. This high shock resistance is due in part to Fairchild's exclusive design feature, where the torsion bar is not required to act as a support for the gimbal.

FAIRCHILD Rate Gyros Have Self-test Capabilities!—No need to pound fists on gyro mounting bulkheads or to jump up and down on wings to check Fairchild gyro performance. Fairchild gyros have self-test capabilities designed in for remote check-out. The gyro gimbal system's freedom of movement can be checked over its entire range of travel, from limit stop to limit stop in most designs. Friction or threshold level, sensitivity, and even damping ratio can be checked from the blockhouse.

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OTHER OUTSTANDING CHARACTERISTICS OF FAIRCHILD GYROS

INPUT RATES (Full Scale) ... ± 5 to ± 800 degs./sec.

MOTOR ... 2 or 3 phase; 26V or 115V AC, 400 cps.

OUTPUT ... 6V, 400 cps, phase sensitive. Other voltages and frequencies available on special order.

LINEARITY ... 0.2% to half scale; 3.5% to full scale.

NULL ... 15 to 40 mv total, in-phase and quadrature can be padded to negligible amounts.

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ECM IN SPACE...

tion when a high speed vehicle penetrates the atmosphere.

Most engineers believe that, despite their very high performance, military space vehicles are not assured of penetrating hostile defenses with impunity. As Cooper sees it, for instance, space vehicles need electronic counter-countermeasures (ECCM) to baffle defensive radars and make penetration easier.

Several possibilities are being considered, involving both passive and active methods. In the former category, Cooper includes:

- **Decoy Clouds**—Since many space vehicles will spend a considerable part of their flight trajectory in a nearly complete vacuum, they could be surrounded with clouds of very light radar-reflecting material ejected from the engine structure or the nose cone. Given a velocity slightly different from that of the vehicle, this material would move through space around the vehicle and make it very difficult for a radar data-gathering system to determine precisely where its real target is.

When this cloud of decoys and the vehicle hit the atmosphere at the beginning of re-entry, many of the decoys will be screened away because of their low weight-drag ratio. However, heavier pieces could be included that would follow the vehicle far enough into the atmosphere to make interception difficult.

- **Radar Camouflage**—Radar-absorbent coatings also are attractive, particularly for space vehicles following vacuum trajectories, since in this case the coatings would not be subjected to intense aerodynamic heating.

But passive ECM also has its drawbacks, Cooper points out. It alerts the enemy's early-warning systems and calls attention to the vehicles it is supposed to shield. Furthermore, radar design is anything but stagnant—future techniques of radar data processing may make it possible to sort out the decoys and quickly identify the space vehicle. Perhaps also infrared (IR) sensors or the like will be developed to locate the vehicle, whose mass, after all, is far greater than that of any decoy. So, in the main, we will probably have to rely on active countermeasures.

ECM designed for use aboard space vehicles will have certain advantages over ground radar.

more on page 152

AT CAPE CANAVERAL...

Styroflex[®] Coaxial Cable

*is a vital part of
the Air Force
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The powerful TLM-18 telemetry antenna now in service at the Air Force Missile Center, Cape Canaveral, Fla., is used for the automatic tracking of missiles and earth satellites. This huge "mechanical ear," specifically designed by Radiation, Inc., Melbourne, Fla., has an effective data reception range of over 1000 miles.

One of the key parts of this highly sensitive device is the $\frac{7}{8}$ " , 50 ohm, aluminum sheathed Styroflex[®] coaxial cable that links the 60-foot parabolic reflector to the receivers. The task of carrying missile-to-earth signals from the antenna to the control building demands a low-loss, high frequency cable with a high signal to noise ratio.

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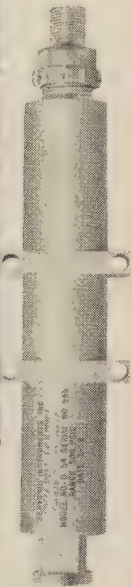
Selected by Aerojet for its ability to withstand severe environments, critical elements of the D-49 are completely isolated and sealed-in-oil within a rugged alloy case to assure long life. Every exposure point has been specially engineered to resist the effects of high temperatures and extreme vibration.

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Range: 0-500 psia
Linearity: $\pm 0.5\%$
Hysteresis: Less than 1.0%
Isolation: . . . Sealed case, oil filled
Weight: 9 ounces
Vibration: to 35 g
Temperature: 300° F max

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Since the spaceborne jammer's signal travels one-way, it comes under the inverse square law; the ground radar, however, must adhere to the $1/R^4$ law.

Ground-defense systems will increase their performance by boosting radar power and the sensitivities of antennas and receivers. At the anti-spacecraft radar, therefore, there will be more radiated power and considerably less received power than you find at the radars used against manned bombers. According to Cooper, spaceborne jamming equipment that could be fully effective under these circumstances stands midway between the limits of higher radiated power and less received power—in fact, pretty nearly where it is in present ECM equipment. The space vehicle ECCM gear might need even less jamming power than that, for the defense radar system will be stretching mightily to meet just the minimum requirements (especially during the early years of space ECM).

At least in its early operational forms, the military space vehicles will be relatively small and will carry light payloads. So the ECCM engineer will have to make his gear extremely light and compact. Recent advances in molecular circuitry and components support the contention of many in the field that active ECCM systems for space vehicles can be designed within practical physical limits.

Automatic barrage and spot-noise jammers, as well as confusion

and deception techniques, can be used against anti-spacecraft radars in much the same way they are used inside the atmosphere today. Another possibility is long range scatter jamming from the surface of the earth. It would rely on the same tropospheric and ionospheric scatter phenomena that are used in scatter communications systems to transmit microwave energy over the horizon. It might be useful for space vehicle ECM in view of the extreme sensitivity and wide-band coverage of defensive radars.

Bizarre ECM ideas are taken seriously

Many engineers are convinced that we can't afford to overlook what may seem radical or bizarre approaches to space ECM. Such ideas as the use of devastating rays against space vehicles are not scoffed at by men of the caliber of Louis deRosa, director of the ECM lab at ITT Labs. He believes that recent developments in high frequency microwave power amplification and focusing techniques may well be the forerunners of the devastating ray.

DeRosa also outlines other highly advanced ideas for space ECM:

- Jam the sensors of recon satellites.
- Trigger the recon satellite so that it releases to you the information it has gathered.
- Trigger an attack satellite so

more on page 154

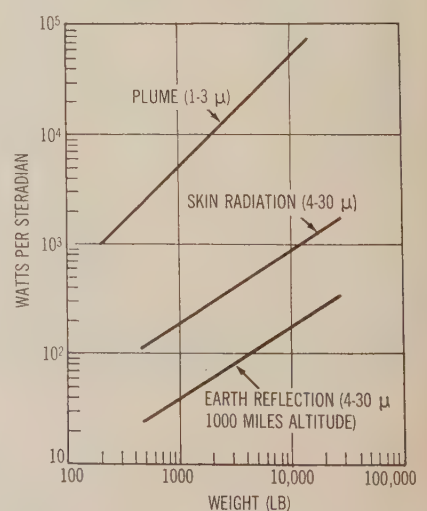
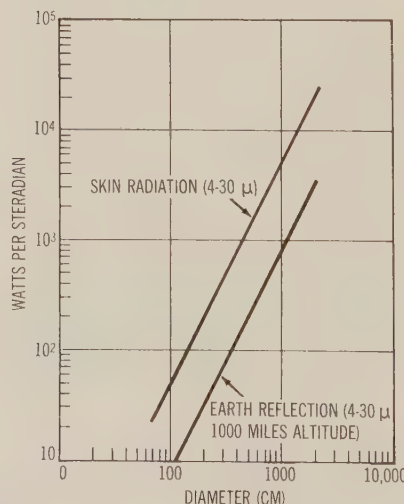
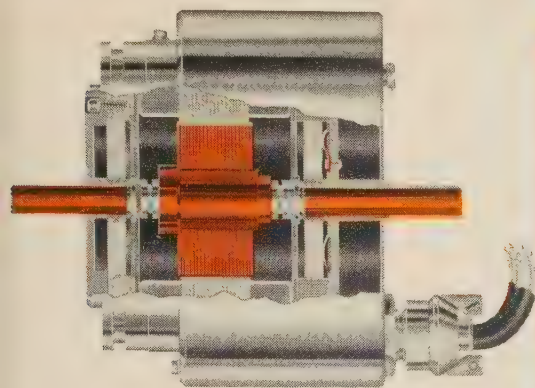


FIGURE 3: Energy radiation from a satellite (left) and a hovering station (right) with 20 deg C skin temperature where emissivity and reflectivity are 0.5.

NOW ultra-accuracy possible in 2-speed servo systems with use of Ketay Vernier Resolvers



Ketay has developed a Vernier Resolver which permits the Systems Engineer to achieve utmost accuracy in his two-speed system. Replacing the fine speed transmitter and associated gearing on one end, and the fine speed receiver with coarse-to-fine gearing on the other end, it provides a basic system accuracy from input to output shaft of the order of 20 seconds of arc, maximum.

Operating on a variable reluctance principle, this resolver accomplishes its gear-up electrically... permitting coarse and fine speed units to be coupled directly. Thus, costly gearing with its contributing errors is eliminated. Also, as a variable reluctance device, it requires no windings on the rotor and therefore no sliprings or brushes. Errors due to brush contact resistance are eliminated, while greater reliability, extremely low breakaway torque and longer life are achieved.

The Vernier Resolver, in conjunction with a standard resolver, may also be used as a highly precise shaft angle encoder.

TYPICAL SPECIFICATIONS

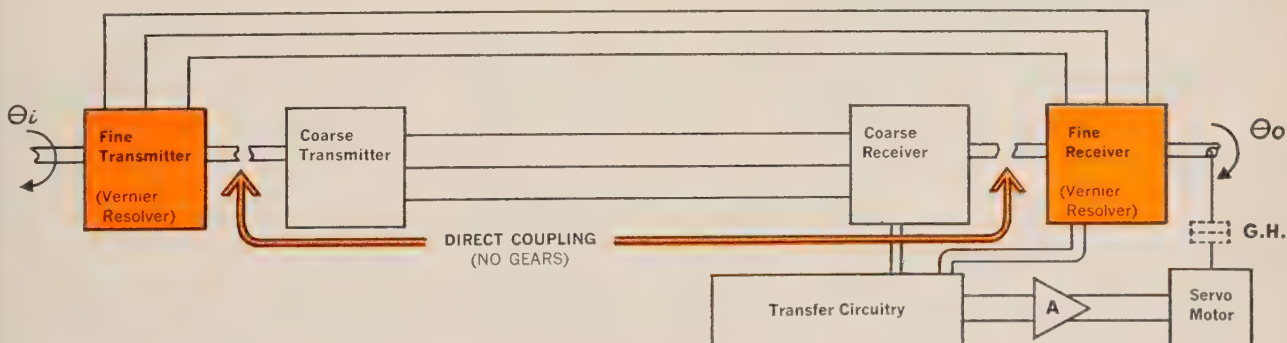
These typical specifications are for a particular vernier resolver designed for a specific application and are included here to give a general idea of what parameters are available. Vernier resolvers can be supplied for a wide range of voltages, currents and frequencies. Electrical to mechanical ratios can be changed to suit specific needs.

Type #	SP.164
Electrical to Mechanical Ratio (Gear up)	64 : 1
Excitation	10 volts, 2.441 K.C.
Error Spread of Null Crossover points (Max.)	12 (seconds)
(3), (2) Error Spread over a Vernier interval (Max.)	4.5 (minutes)
Maximum over-lapping error between intervals—approx.:	21 (seconds)
Peak Output Voltage: (volts)	$2.3 \pm 10\%$
Peak Output Voltage on reference winding: (volts)	$2.5 \pm 4\%$
Open Circuit excitation current (untuned) (amps)	$0.64 \pm 4\%$
Open Circuit excitation current (tuned) (amps)	$0.065 \pm 10\%$
Open Circuit power (watts)	$0.65 \pm 10\%$
Max. Starting Torque (in-oz.)	0.1
Input impedance (ohms)	$15.6 \pm 4\%$ $\angle 84^\circ$
Null Voltage at Zero Points: (total rms)	7.5 mv.
Peak Third (3) harmonic voltage (mv.)	8.5
Phase Shift of output to input, approx.	3°
Ambient temperature (C)	-20° to $+70^\circ$
Weight—approximately	8 lbs. 13 oz.

- NOTES: 1. Configurations, size, weight, etc. can be modified to suit specific applications.
2. Error spread can be trimmed down to value of over-lapping error or less.
3. Error is for unit being used as 2 Phase Transducer.

Submit your problems to us and a qualified Ketay engineer will show you how a vernier resolver may solve them.

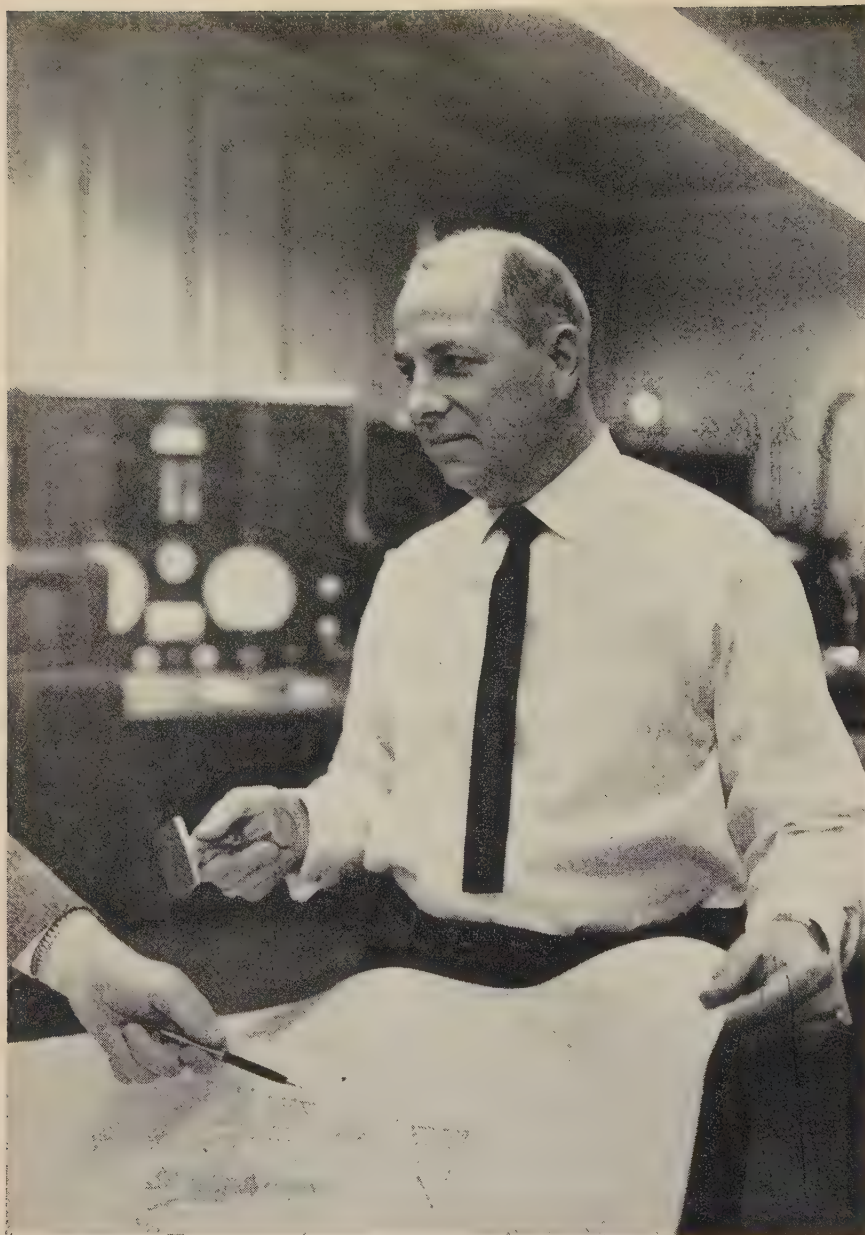
USE OF VERNIER RESOLVER IN TWO SPEED SYSTEM



KETAY DEPARTMENT

NORDEN
DIVISION OF UNITED AIRCRAFT CORPORATION
Commack, Long Island, New York

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His name is Robert Ulrich. He's the Senior Project Engineer on Fuel Injector Development with Delavan. He's been with Delavan ten years, and has designed fuel injectors which are now standard on many of the world's most advanced jet aircraft and missiles. Men like Bob Ulrich, concentrating their considerable talents to fuel injector development, have made Delavan the world's largest nozzle specialist. They're the main reasons leading turbo-jet, rocket and APU manufacturers rely on Delavan for fuel injection problem solving.

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that it releases its weapons at your command.

- Put up a jammer satellite in the same orbit with your recon vehicle to "run interference."

- Put up an ECM satellite in orbit next to a hostile recon satellite to jam the other satellite or destroy it as it blows up itself (*Fig. 1*). Either action could be performed on command or on an elapsed-timed basis (to avoid the recon satellite's ECCM).

Like other forms of electronic warfare, IR recon-surveillance and countermeasures stand to gain as space applications open up—atmospheric attenuation and background backscatter, the worst headaches of IR detection, will no longer be around.

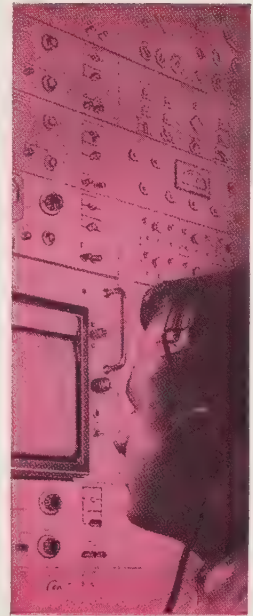
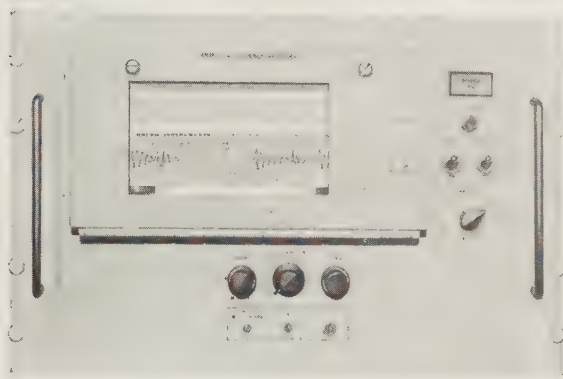
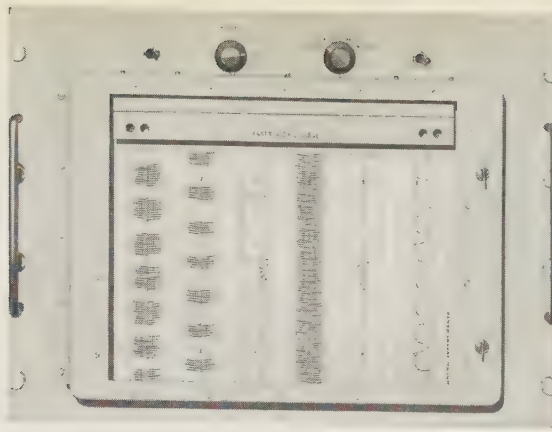
However, for the present and for early space applications, the picture is not rosy. All efforts to detect any of the going satellites by IR reportedly have failed, except in the case of targets reflecting sunlight.

This seems to back up calculations by ACF Industries' Avion Division that show the chances of detecting satellites or other relatively static, long range objects with ground IR to be definitely limited to the visible region of the spectrum (*Figs. 2 & 3*). Their sunlight reflection would seem to provide the only means of detecting orbiting vehicles with IR (from either ground or space), since these vehicles would generate practically no heat in the vacuum of space. Combined optical-IR sensors may widen the detection spectrum somewhat.

Experts agree that space-to-ground IR recon-surveillance of ICBM launch sites and ICBMs after they have broken cloud cover will be widespread. Space-to-space IR detection will be another matter, though—particularly at long range. Of course, once you've detected a target, the extreme sensitivity of IR sensors in space will let you track even the faintest radiator.

If spacecraft-to-spacecraft warfare ever becomes a serious possibility, experts believe, then IR and optical techniques will play a big role in search and fire control as well as in defense systems. If one spacecraft wanted to attack another, it would have to use power for maneuvering and would be more easily detectable by IR. Detection by IR might also rely on the interaction of a moving body with vestiges of the ionosphere, which leaves a trackable wake.—BK

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SPACE/AERONAUTICS



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From every nut and bolt to the shipping crate, fully militarized Brush Direct Writing recording Systems are *originally* built to meet military specifications.

That's why they are performing every imaginable task of data acquisition and recording at U. S. and NATO installations throughout the world. These electric writing systems have proved their unexcelled reliability... from the Operations Monitor that will record 120 separate operations at the instant they occur... to the Analog and Sequence Recorder that simultaneously records both analog data and sequential events. And, they are built for maximum performance in the hands of non-technical personnel.

Brush equipment is already at work putting evaluation data in writing for a whole new generation of weapons. When the weapons become operational, Brush MIL Recorders are a vital part of the system. This experience is unique in the industry. *Before* prototype design becomes a problem—call, write or wire Brush for complete details.

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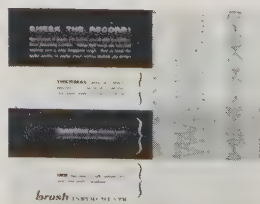


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Simulator checks out radio-radar AJ operation

- Simulation before breadboarding
- Ultimate accuracy of 0.1 db foreseen

by **John Lambert**, Project Engineer, Electronic Systems Evaluation, Defense Systems Dept., General Electric Co.*

ANTI-JAMMING (AJ) circuit design in aerospace electronic systems is complicated by the fact that jamming modulation and receiver non-linearities are extremely difficult to analyze. Many existing systems are marginal in an electronic countermeasures environment. The system designer can only rely on experimental data on AJ circuit performance, yet often the design of a

* Defense Systems Dept., General Electric Co., Atlantic Bldg., Syracuse, N. Y.

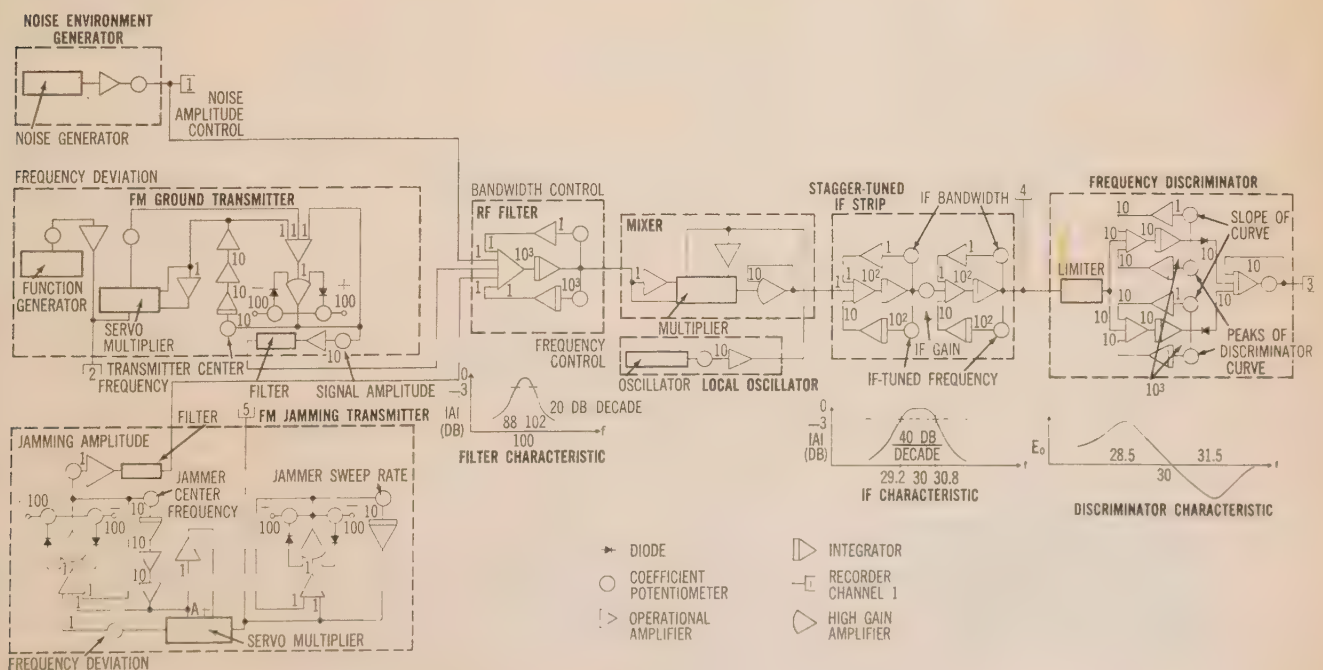
new system must be frozen before the AJ circuits can be optimized experimentally.

To get out of this dilemma, you can build a low frequency analog model of your system and use it to evaluate AJ circuits and jammer effectiveness. This is the approach that led to the General Electric Electronic System Evaluator (GEESE). This unit can simulate new systems long before any electronic equipment is breadboarded. When it is used, all subsystems, including those covering AJ performance, can be optimized early in the design cycle.

In one application, a model of an FM receiver was simulated on GEESE (Figs. 1 & 4). The IF frequency was assumed to be 300 kc with a 15-kc bandpass and was scaled down 10,000:1 (to 30 cps with a 1.5-cps bandpass). The audio rate was assumed to be three

more on next page

FIGURE 1: Computer diagram for the simulation of the FM receiver of Figure 4.



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- interchangeable with existing Deutsch DM (MS) miniatures and hermetics
- meet all applicable requirements of MIL-C-26482

So why worry? For details on completely reliable snap-in type connectors, contact your local Deutsch representative or write for data file E-4.

The Deutsch Company

ELECTRONIC COMPONENTS DIVISION
Municipal Airport • Banning, California



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AJ OPERATION . . .

kilocycles and scaled down to 0.3 cps.

Since the carrier frequency is arbitrary, a 100-cps carrier was chosen. It was frequency-modulated at 0.3 cps, with a maximum deviation of 0.7 cps. The local oscillator operated at 130 cps, and the 10^{-4} system scaling was carried from the mixer through the entire system.

Simple model represents satellite receiver

Frequency scaling is important in the use of GEESE since the system simulation at low audio frequencies makes it possible to record all signals and observe all transient and steady-state phenomena while interference signals are fed in or system parameters are changed.

With our simplified model, we can represent a satellite receiver. Because of the orbital motion of the satellite, the signal from the

more on page 160

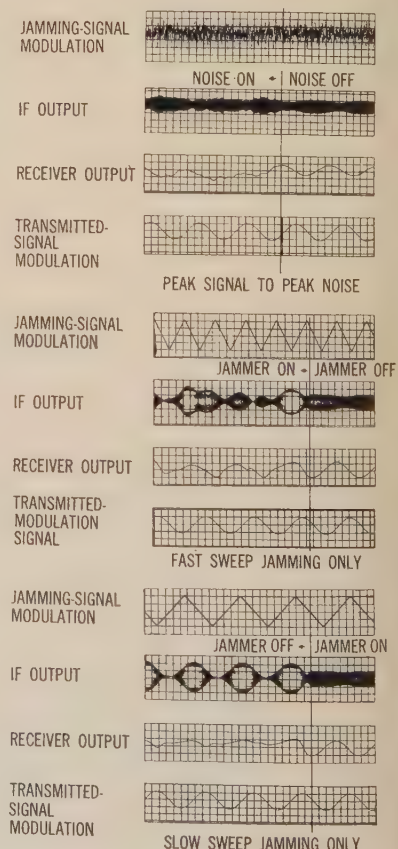
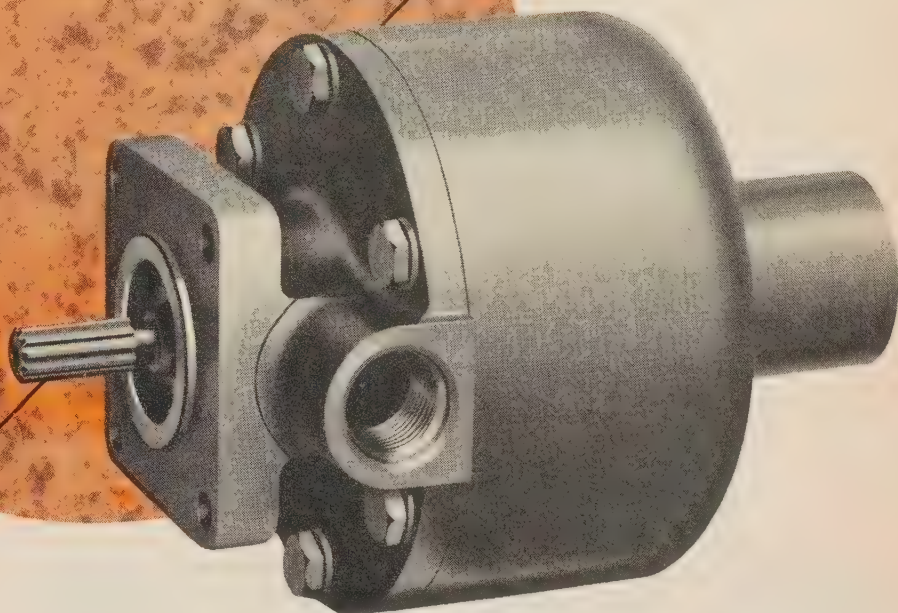


FIGURE 2: Receiver waveform recordings. The IF output is amplitude calibrated for signal strength; the ratio of peak signal to peak noise is -3 db.

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Model shown has these performance characteristics: Pressure—to 1000 psi; flow—4000 PPH, speed—4000 RPM; temperature range—65° to 300° F, weight—5 lbs, size—4 $\frac{3}{32}$ " dia., 5 $\frac{5}{8}$ " long.

Designed for a service life of 1000 hours, the new Vickers vane pump was proved in more than 3400 hours of rigorous testing over the last two years (see Bulletin A-5242). Wear compensating parts and new material combinations extend service life.

Write for Bulletin A-5242 for more details.

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AJ OPERATION . . .

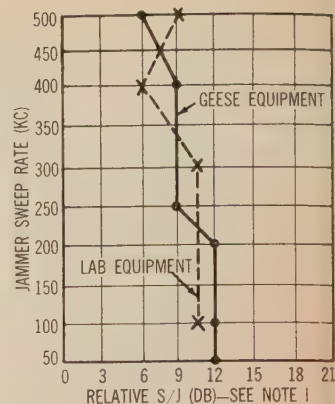


FIGURE 3: Jamming effects on the lab model of a sophisticated phase-locked AFC receiver and on the same receiver simulated on the GE electronic system evaluator (GEESE). The circles indicate breakdowns of the phase-lock loop. The frequency deviation of the CW jammer equals that of a 100-kc jammer centered on the signal frequency. For security reasons, the absolute S/J ratio is not shown.

ground transmitter (and from any ground-based enemy jammers) in such a case, will vary as a function of position, antenna pattern, antenna tracking errors, and time.

The orbit can be programmed directly into GEESE, since the dynamic orbit of the satellite can be solved by analog computer. The satellite is programmed with respect to the ground transmitter and the jammer so that the signal strengths at the satellite of both transmitter and jammers will vary continuously as functions of position and time.

Signal-to-jam ratios were changed discretely

Antenna pattern characteristics are simulated with non-linear equipment and varied as functions of position and time. The attitude of the satellite is included, so that, if necessary, the minute tracking errors can be taken into account. Anomalies are allowed for by the use of digital-to-analog automatic programming and so control the signal strengths at the input to the satellite antenna. Along with these dynamic characteristics, the effects of atmospheric attenuation and noise are simulated.

In our sample case, the signal-to-jam ratios were changed in discrete steps. When this method is

more on page 164



Safety Valve **FOR AN ASTRONAUT**

If America's first man-carrying rocket runs into trouble, a unique Donner device will play a vital role in bringing the Astronaut safely back to earth.

Known as a "maximum altitude sensor," the all solid-state system is essentially a fixed purpose miniature analog computer housed in a magnesium case only five inches long. Installed in the capsule, it goes into action if it is necessary to abort the rocket flight before the Astronaut's escape tower is jettisoned.

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The Donner device, which was developed for McDonnell Aviation with the approval of NASA, provides programmed time delay that operates rescue devices at maximum altitude.

Under abort conditions, the maximum altitude sensor provides output information which will:

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2. Energize the system which causes the escape tower jettison rocket to fire. With the tower separated, barostats are armed to open parachutes and furnish the Astronaut's capsule a safe descent.

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Donner's maximum altitude sensor is another product from a firm specializing in the manufacture of accurate fixed and general purpose analog and digital systems designed to analyze, measure, and control inputs interlocking time, acceleration, jerk, velocity, and other dynamic inputs.

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MARQUARDT/OGDEN RAMJETS FOR USAF-BOMARC PROVE 100% RELIABLE



Marquardt/Ogden delivered its first production engine to the Air Force in June 1957, one month ahead of schedule. This was achieved despite the problems of creating, building and implementing a modern production facility and staffing it with qualified engineers and technical personnel. In the more than two years since, each and every delivery has been as-per-contract-schedule, while Ogden ramjets have proved 100% reliable in all test flights of Bomarc IM-99A.

By strict adherence to a realistic learning curve, Ogden Division currently delivers its supersonic ramjets at far less than their mid-1957 delivered cost—this despite the ramjet engine system's relatively early stage of maturity.

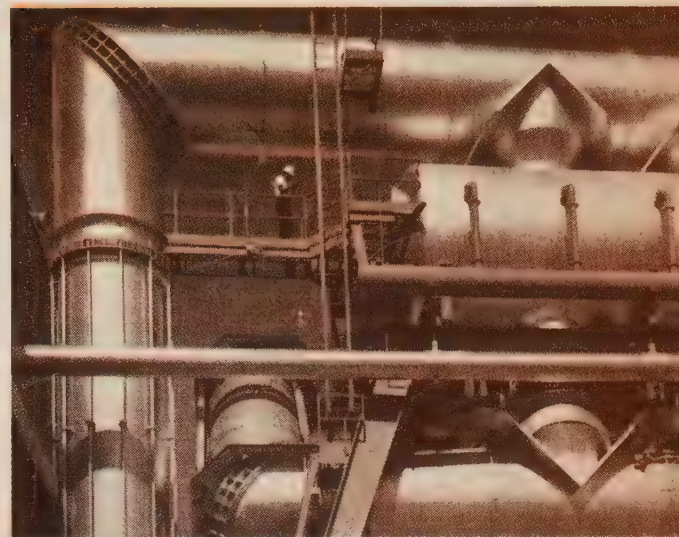
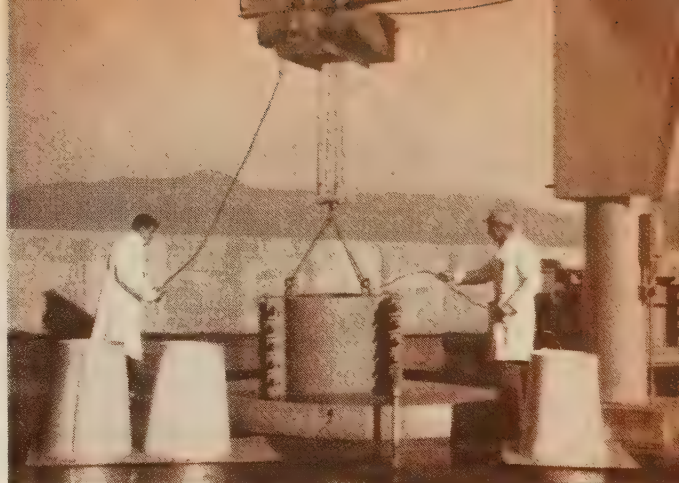
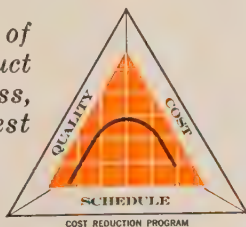
Recent expansion and additions further enhance Marquardt/Ogden's capability. In 1958 the plant doubled floor space to almost ¼ million square feet, with numbers of employees increasing 93%. 1959 marked Ogden Division's addition of a first-of-its-kind Spin Forge and completion of a new facility for explosive metal forming. Ogden's USAF-Marquardt acceptance test facility at Little Mountain gives the Division full-plant capability.

Marquardt/Ogden is now capable of producing space-age hardware in all of its basic configurations—cones, cylinders, rings, parabolic shapes—using the most sophisticated of space-age metals.

Responsible for Marquardt/Ogden's record are: a creatively cost-conscious management team headed by Mr. D. K. Tasker (pictured left); early application of industry's newest and most advanced production and metal working techniques; a facility cited by *Factory Magazine* as one of America's top ten; and the efforts of the Division's nearly 2,000 men and women workers. All combine to provide Department of Defense and Weapon Systems Managers with a unique capability for the on-time delivery of reliable space-age hardware at minimum cost.

For additional production capability specifics, you are invited to contact: Manager, Customer Relations Department, Ogden Division, The Marquardt Corporation, 1000 West 33rd Street, Ogden, Utah.

Current expansion creates a number of outstanding opportunities for: Product Development, Materials and Process, Manufacturing and Production Test Engineers; and skilled machinists.



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OGDEN DIVISION

THE Marquardt CORPORATION

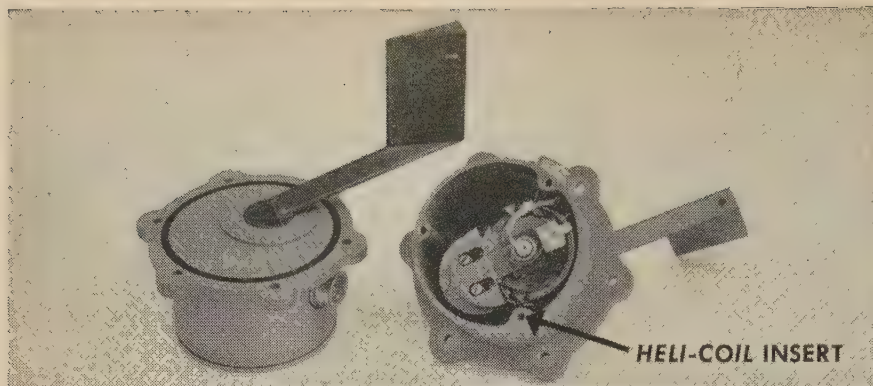
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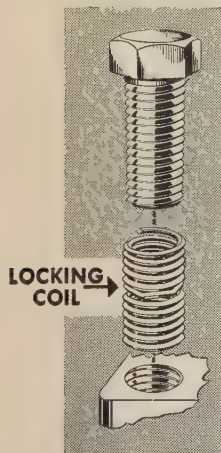
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Critical Electronic Controls Get Internal-Locking, Protective Threads

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Electronic control devices for aircraft and missiles, like this angle of attack vane transducer made by U. S. SCIENCE CORPORATION, LOS ANGELES, CALIF., have to withstand severe vibration, impact, corrosion and temperature change. They must be made of light materials and still have strong threads—able to hold fasteners tightly and stand frequent assembly and disassembly.

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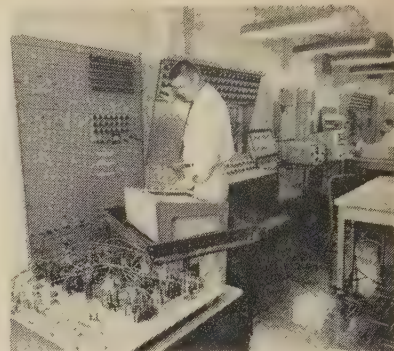
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IN CANADA: Armstrong Beverley Engineering Ltd., 6975 Jeanne Mance St., Montreal 15, Que.

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AJ OPERATION . . .



PRESENT GEESE facility at GE Defense Systems Dept. An improved facility is under construction.

used a variety of anti-jam devices and techniques can be inserted, and their interference can be evaluated in each case.

The recordings of *Figure 2* illustrate GEESE's ability to record any signal within the system as well as the effects of natural friendly, and enemy-produced interference environments.

Channel 1 shows the audio signals carrying the information. Channel 2 is the output of the simulated receiver; ideally, it should be a reproduction of channel 1. Channel 3 is an amplitude plot of the IF strip. Channel 4 is the modulating signal of the jammer. The jammer in the second and third cases is a frequency-modulated transmitter comparable to a carcinotron. It has a maximum deviation of 10 cps and is swept at 0.28 and 0.5 cps. These values correspond to a 100-kc deviation at 2.8 and five kilocycles.

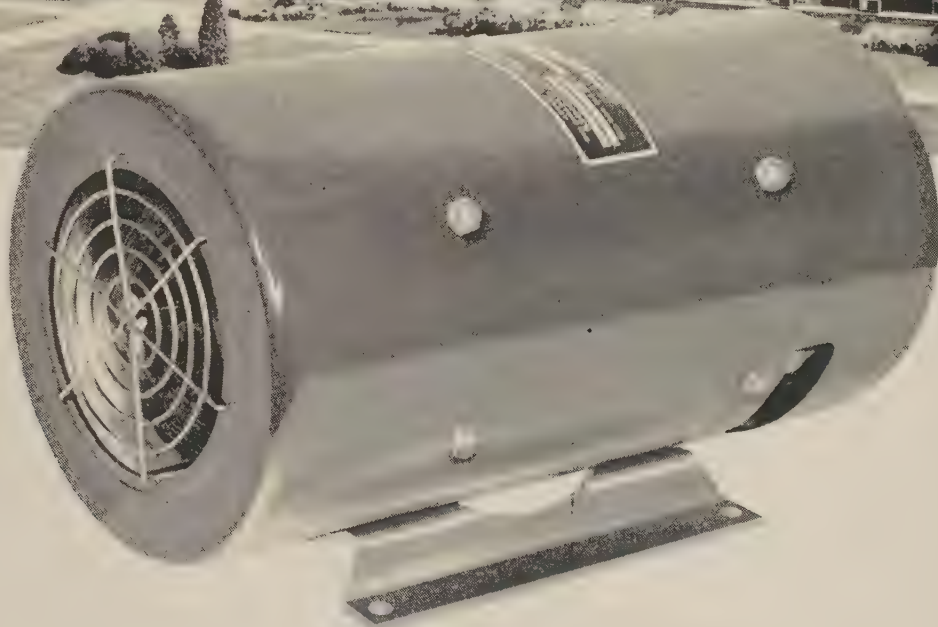
Jam and no-jam periods are compared

The recordings show the interference signals and the effects of the interference in the IF stages and at the output. There is a portion of time on each recording when the jamming is not turned on and another showing the effects of successful jamming. Recording 1 shows the effect of noise jamming; recording 2, the effect of carcinotron jamming at 0.5 cps rate (representing a five-kilocycle sweep rate); recording 3 the effect of carcinotron-sweep-type jamming at 0.28 cps (2.8 kc).

In developing a system model for GEESE evaluation, the programmer starts by setting up a linear, low

more on page 166

NEW CHATHAM Y-SERIES Airborne Transformer Rectifiers



...lightest, smallest of them all

Chatham's new bantamweight Y-Series transformer rectifiers weigh up to $\frac{2}{3}$ less than competitive models with comparable ratings. And they occupy just $\frac{1}{4}$ the volume.

These precision miniatures in Chatham's series are rated from 20 amps to 200 amps and deliver 28 volts dc. The 200 amp unit, 28VS200Y, weighs under 17 pounds, measures a trim 11 inches, and occupies only 310 cubic inches. The other units in this series are proportionately lighter and smaller. All the units work off 200 volt, 3 phase, 400 cycle aircraft power supplies.

Only Chatham's exciting departure from conventional transformer design makes the compact Y-Series possible. For the first time a transformer has been designed with a compact symmetrical 'Y' coil configuration. Aside from drastically slicing weight and volume, this remarkable design assures optimum performance by keeping flux link-

ages uniform while minimizing possible spurious linkages. These characteristics and the quality components engineered into the Y-Series provide for low ripple voltage and produce extremely flat voltage output from no-load to full-load.

All the silicon rectifiers and the sturdy cast aluminum heat sinks used in the Y-Series were specifically designed for this application. You're sure of getting the highest dependability in the best and most efficient power conversion package. The Y-Series features fan cooling which offers complete mounting flexibility in any atti-

tude. Motor operation is guaranteed for 7500 hours at 71° C and for 2000 hours at 125° C. A very minimum of 10,000 hours and 2500 hours, respectively, is expected.

In addition to the Y-Series TR units, Chatham also makes inverters and other power conversion equipment for missiles and other aircraft industry uses. You can get a complete description of Chatham power conversion equipment by writing for brochure T-26. Chatham Electronics, division of Tung-Sol Electric Inc., Livingston, N. J. Sales Offices: Culver City, Calif., Dallas, Texas. TWX: NK193

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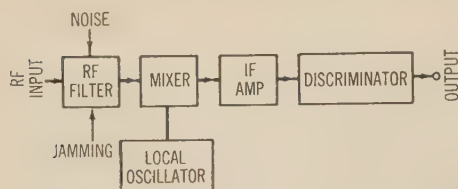


FIGURE 4: FM receiver simulated in analog form by GE's electronic system evaluator.

frequency model of the system, working from the system block diagram. This model contains the exact linear transfer and is usually

within six decibels of experimental results.

From the linear model, the most important system parameters are

determined. Next the linear model is refined by programming into it the two or three most important non-linear and second-order functions (e. g., the actual first-mixer-characteristic curve, local-oscillator harmonics, non-linearities in the preamplifier, and AGC response). These non-linear characteristics are estimated on the basis of circuit diagrams and/or of discussions with the circuit designer.

After a few weeks, accuracy should be three db

The programming of non-linear functions is straightforward. After several weeks of intensive effort, the system model should be accurate to within three decibels.

So far, GEESE has not been used in any case requiring an accuracy better than three decibels. Test repeatability on actual system hardware is normally within three decibels.

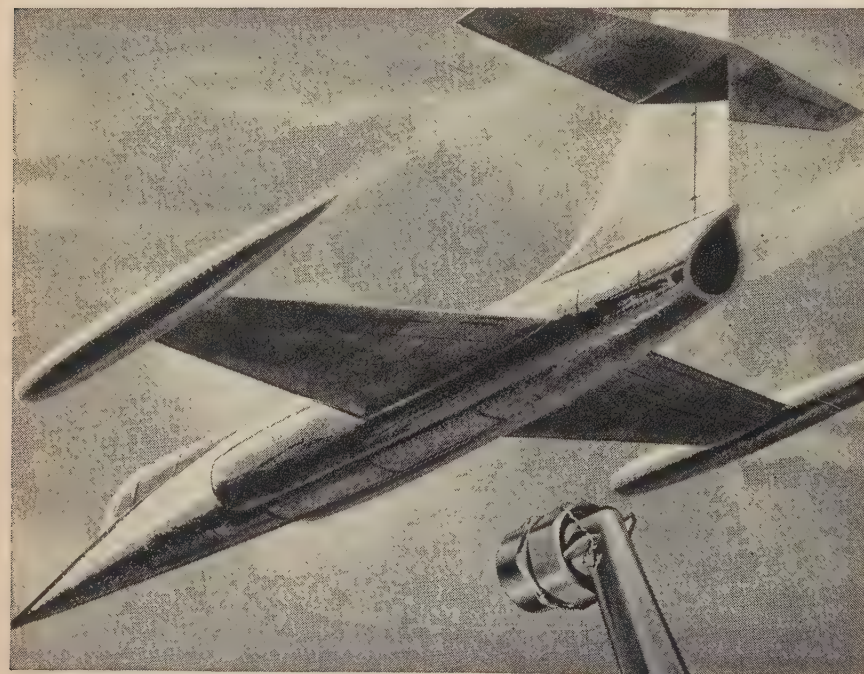
What would be the ultimate accuracy if all second-order and non-linear equipment characteristics were measured and programed into the model? No direct experimental work has been done to answer this question. From the accuracy limits of the basic GEESE components (mixer, phase detectors, function-generating equipment, etc.) one can infer that a model of a unit like a receiver could be made accurate to within 0.1 db.

Accuracy of one decibel is hard to get

A complete system containing 10 major units like receivers, transmitters, data links, etc., should be reproducible to within one decibel. In practice, though, an accuracy of one decibel or less is very hard to get.

Analytic checks are made in every evaluation to show that the results are within the required accuracy. By combining communications and control theories, a system analysis of the steady-state performance as a function of signal-noise ratio can be achieved.

Figure 3 shows the close correlation between results predicted by GEESE and actual prototype test results. In the case shown, the criterion for successful operation of the jammer is whether or not it breaks the phase-lock loop (frequency tracking loop).—End



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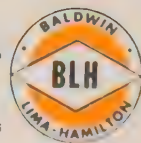


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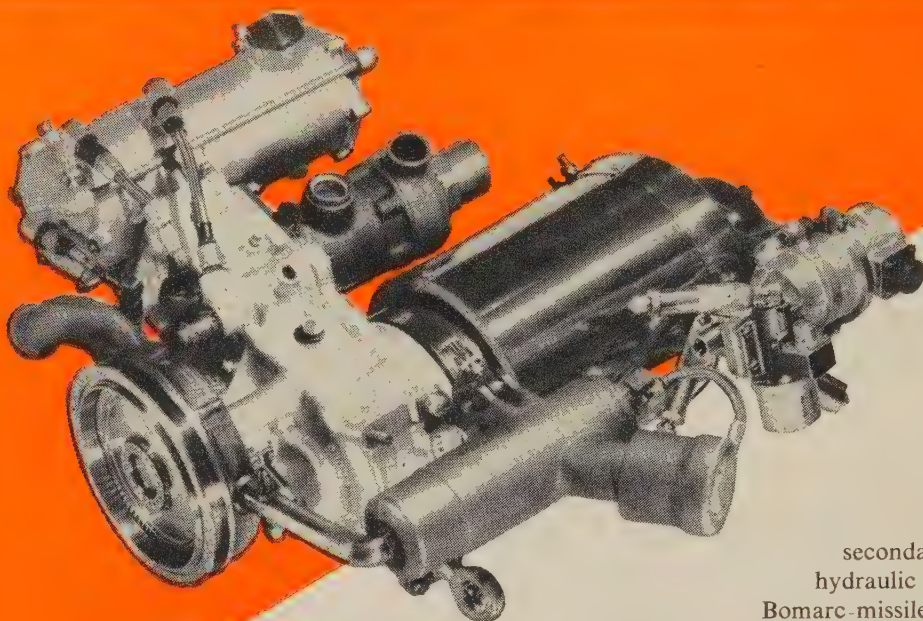
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TAPCO POW



BOMARC APU

This APU is a self-sufficient secondary power unit which provides hydraulic and electrical power for the BOMARC-missile. It maintains constant speed and recovers very rapidly from sudden changes in load demand. The turbine-driven unit utilizes energy obtained from the decomposition of pre-packaged monopropellant fuel. Unique features include a pressurized fuel system which eliminates fuel pump requirement, all-altitude lubrication system, and a constant speed electro-mechanical control not affected by load demand. The unit is now undergoing Military Preflight Rating Tests.

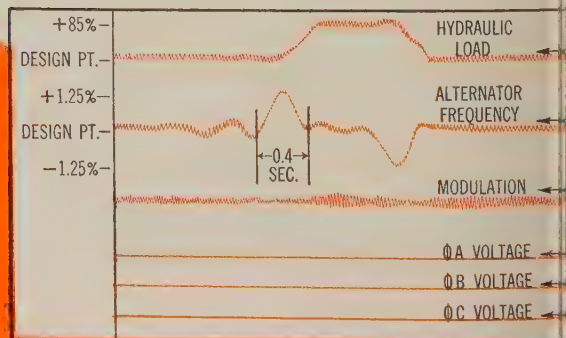
This trace shows the ability of a combined electrical and hydraulic power system to generate high quality electrical power when subjected to large changes in the hydraulic load. Note that the transient response occurs within 0.4 sec. and that maximum excursion in electrical frequency is 1.25% of the steady state value. The steady state frequency is below 0.1 Hz and the voltage modulation is 0.14%.



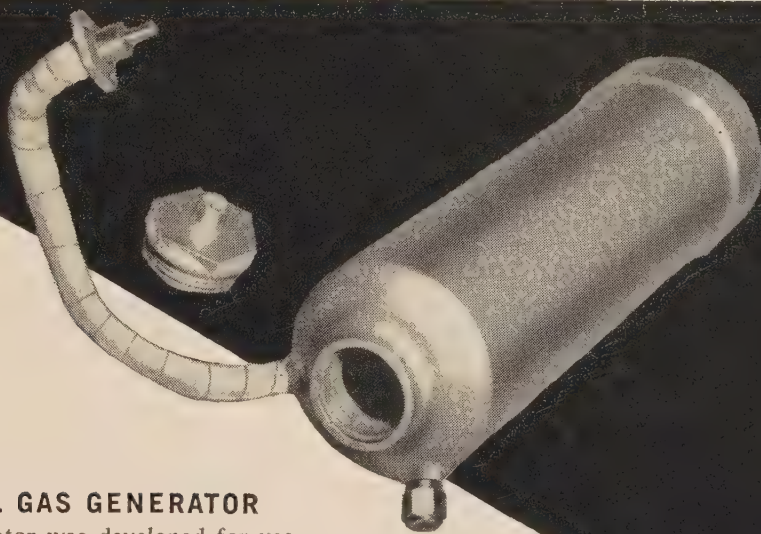
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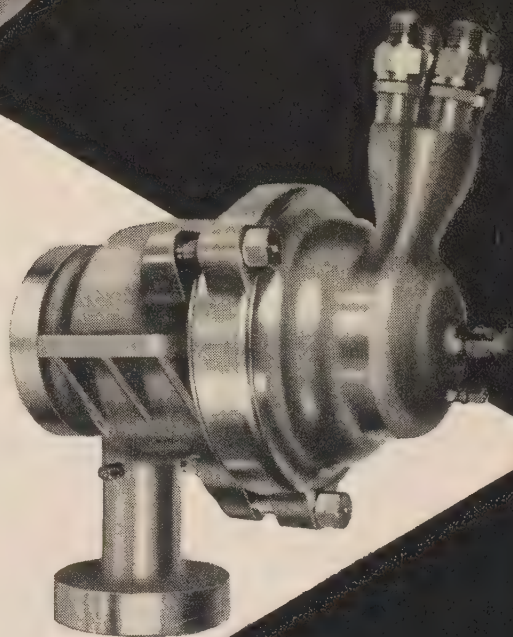


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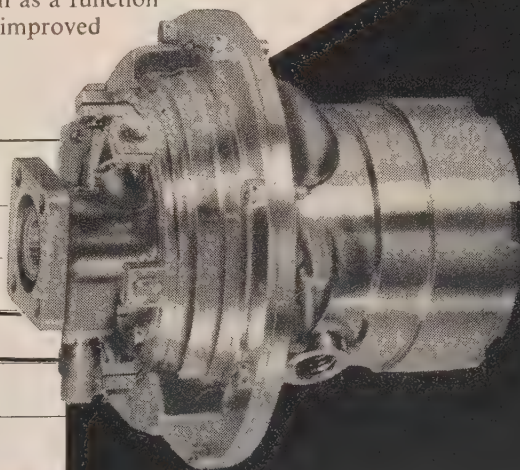
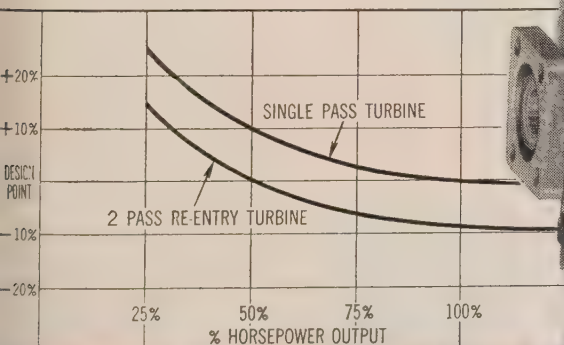
Currently in active service are TAPCO-designed and produced lightweight hydrazine gas generators ranging from 50 to 12,000 h.p. These generators are capable of withstanding severe G-load and vibrational requirements during sustained operation. TAPCO facilities are completely integrated for the economical development and manufacture of gas generators, with very short lead time required.



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The re-entry turbine is a new concept that allows lower specific fuel consumption by re-circulating gases through a single turbine wheel. Unit shown, with integral solid-propellant gas generator, in final stage of development.

Graph below shows Specific Fuel Consumption as a function of power with single and 2-pass turbines. Note improved performance with the re-entry turbine.



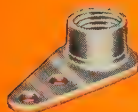
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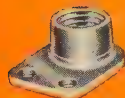
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MF6031



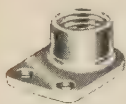
MK3400



MK1031



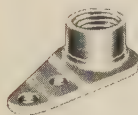
MF1400



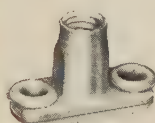
MK4031



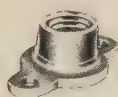
MF6000



MK2400



MF19058



MK1400



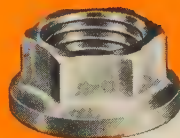
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G19199

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K7000



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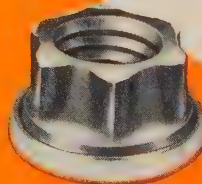
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H33



HW14



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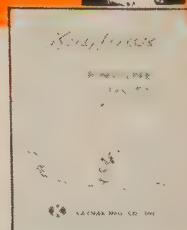
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Wide bandwidth, high power handling abilities needed for **ECM antennas**

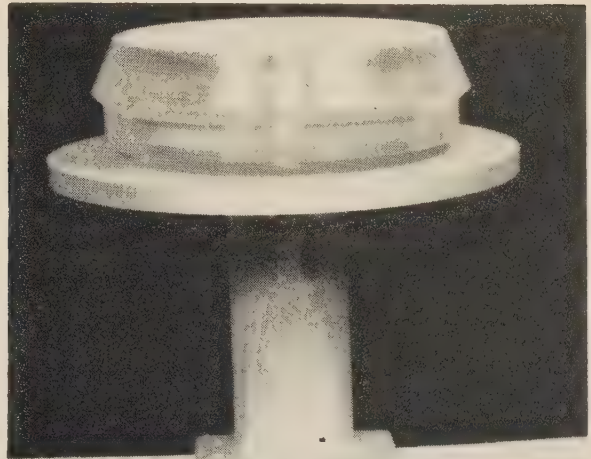


FIGURE 1:
Omnidirectional
end-fire-type
horn antenna.

- Radiation pattern, input impedance pose toughest design problems
- Size and weight must be minimized

by **E. C. Hatcher**, Chief, Antenna Section, Electronics Specialty Co.*

SINCE electronic countermeasure (ECM) systems require broadband electronic equipment, the associated antennas must be broadband designs, too. They must also be able to handle large amounts of continuous power. An ECM antenna is called "broadband" if its electric characteristics remain essentially constant over a bandwidth of 2:1 or more.

Three electric characteristics must be considered in the design

of broadband ECM antennas:

- the radiation pattern;
- the polarization of the radiated signal;
- the voltage standing-wave ratio (VSWR) of the input impedance of the antenna.

Control of the radiation pattern and the input impedance represent the bulk of the design problem. It's also vitally important to keep size and weight to a minimum. Furthermore, the antenna usually must be flush-mounted.

Many antenna types have been

developed to meet the diverse electric and mechanical requirements of ECM systems. The scimitar antenna is often used when vertical and horizontal polarization are desired and an external installation is feasible (*Fig. 6*). It was developed from the equivalence principle of S. A. Schelkinoff, which states that, if an antenna is sufficiently long and defined entirely by angles, input impedance and radiation patterns are independent of frequency.

Electronic Specialty has developed a variation of the scimitar antenna known as the "hatchet" (*Fig. 3*) to provide additional horizontal polarization. This design also has a greater impedance bandwidth than the scimitar.

Scimitar antennas are usually designed to provide a maximum

more on next page

*Electronics Specialty Co., 5121 San Fernando Rd., Los Angeles 39, Calif.

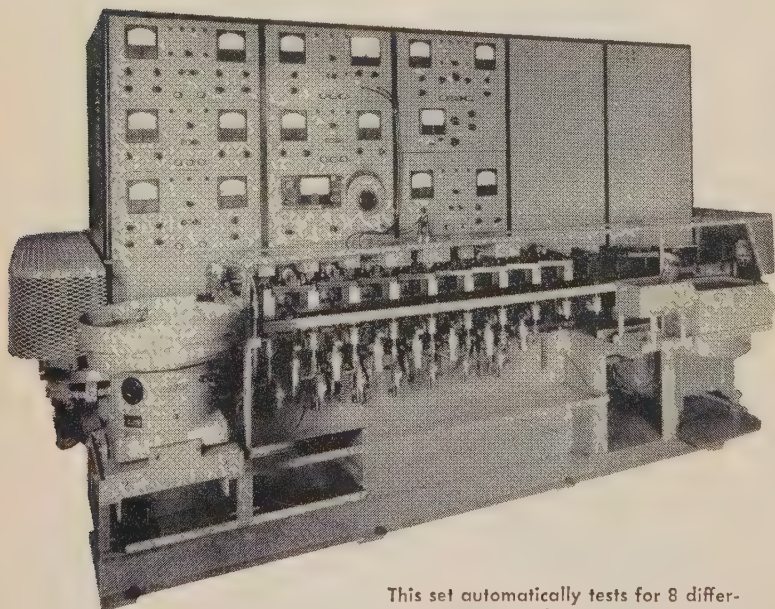
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ECM ANTENNAS . . .



FIGURE 2: Scimitar antennas are used for external installation when vertical and horizontal polarization are desired.



FIGURE 3: Two types of hatchet antennas.

bandwidth of 2.5:1. This represents a compromise between impedance radiation patterns and polarization.

On high speed vehicles, flush-mounted antennas must be used to prevent aerodynamic drag. These antennas should be compact, so that they will be compatible with other equipment in the craft. The leaky-wave antenna fulfills this requirement. It is a waveguide that has perforations on one side, so that the energy in a wave traveling down the waveguide leaks out gradually and radiates into space. By controlling the number of perforations, the rate of leakage, and the phase velocity of the antenna, a radiated beam can be positioned in a wide range of directions.

Leaky-wave antennas may be designed for either vertical or horizontal polarization. To obtain a horizontally polarized end-fire beam, a distribution of horizontal electric current elements oriented at right angles to the end-fire direction or of vertical magnetic current elements is needed. For a vertically polarized end-fire beam, you need a distribution either of horizontal magnetic current elements oriented at right angles to the end-fire direction, or of vertical electric current elements (Fig. 4).

For limited-sector coverage, vari-

more on page 174

At 00^h00^m01^s GMT, April 1, 1960, Martin logged its 490,932,000th mile of space flight



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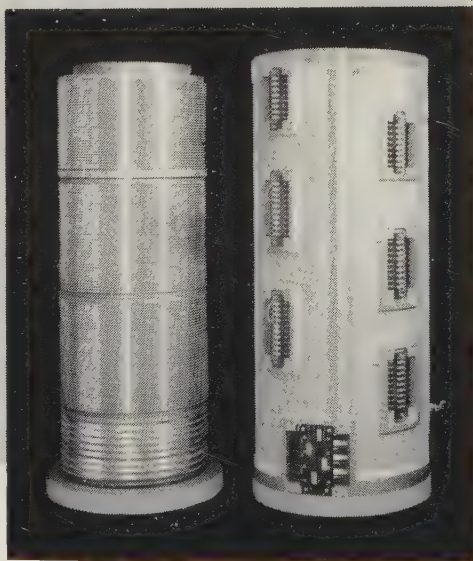
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This is typical of the many successful design and manufacturing applications which Electro-Tec performs for leading manufacturers of radar, gyros, inertial guidance, instruments, and switching.

*Pat. No. 2,696,570 and other patents pending

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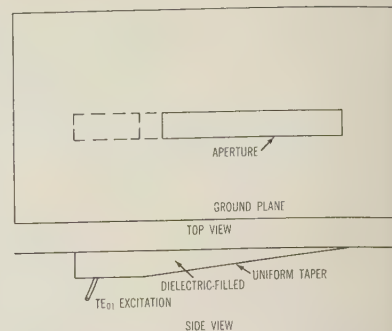


FIGURE 4: Vertically polarized leaky-wave antenna.



FIGURE 5: Electromagnetic horn antennas are used for limited sector coverage.

ous electromagnetic horns are used as ECM antennas. The horn radiates a beam along its axis, the width of which depends on the size of the horn aperture. Horn antennas are both horizontally and vertically polarized and are easily adapted to circular or variable polarization (*Fig. 5*).

Circularly polarized horns use dielectric lenses

Electronic Specialty has developed two novel circularly polarized horns. These use dielectric lenses in their apertures for beam-shaping. The type shown in *Figure 6* has an H-plane beamwidth of 120 deg over a 1.6:1 bandwidth. *Figure 1* shows an omnidirectional end-fire-type antenna.

For low frequency uses (VHF, UHF, etc.), a circularly polarized antenna with its radiation directed along its axis is required. A helix mounted in a cavity is often used. The cavity helix inherently has broadband properties, showing desirable pattern, impedance, and polarization characteristics over a 2:1 bandwidth.

The spiral antenna is often used for monitoring enemy transmission.

more on page 176

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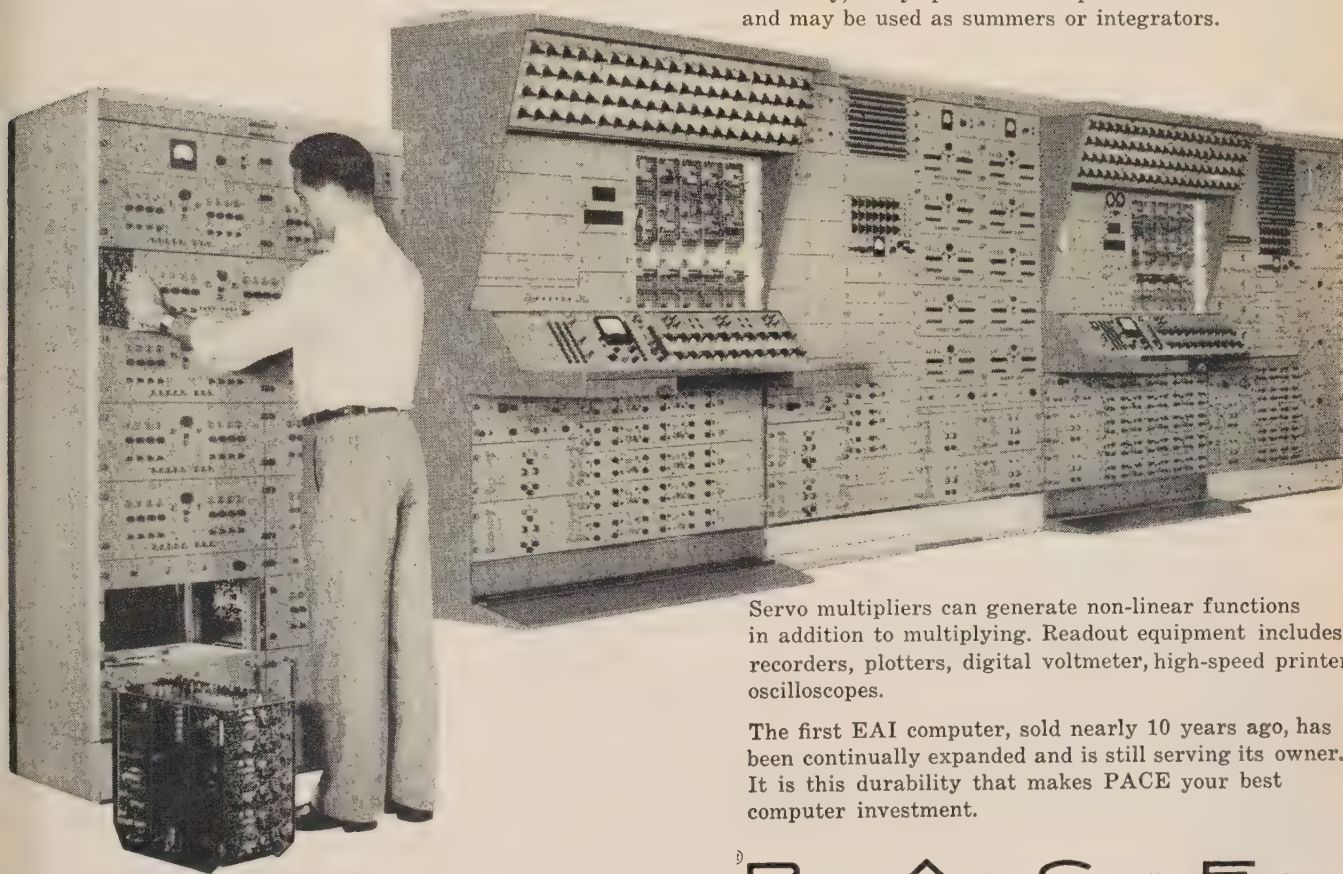
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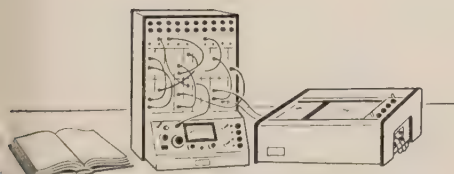
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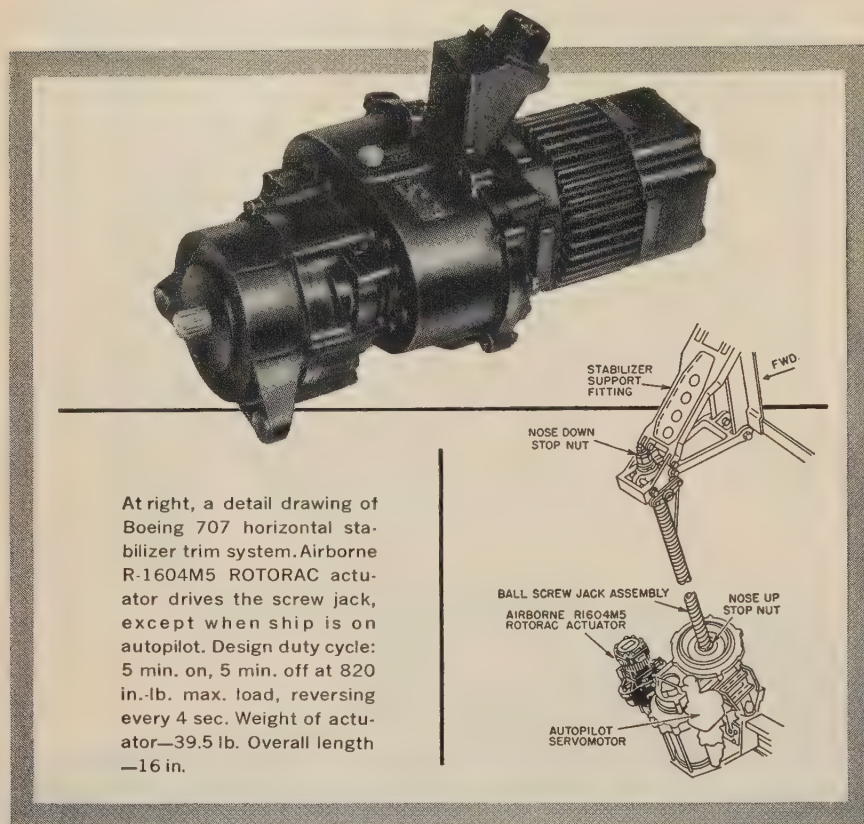


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AIRBORNE SPECIAL ACTUATOR

POWERS 707 TRIM SYSTEM



At right, a detail drawing of Boeing 707 horizontal stabilizer trim system. Airborne R-1604M5 ROTORAC actuator drives the screw jack, except when ship is on autopilot. Design duty cycle: 5 min. on, 5 min. off at 820 in.-lb. max. load, reversing every 4 sec. Weight of actuator—39.5 lb. Overall length—16 in.

Because of its function—operation of a primary flight control on Boeing's 707 — this Airborne ROTORAC large special actuator must provide the utmost reliability under almost continuous off-on-reverse type operation. And its response must be quick, even though maximum torque and acceleration are limited by specification — to avoid inadvertent structural overloads.

To control torque, Airborne developed a special friction clutch which limits output to 1500 in.-lb. maximum and yet will transmit 1200 in.-lb. under any condition. Controlled accelerations were achieved by balancing the inertia characteristics of all rotating parts

and of the external load against the carefully tailored performances of the motor and servo clutches. Result: smooth acceleration from 0 to 180 rpm in 0.4 second and shock-free reversal in 0.1 second, both at full load.

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ECM ANTENNAS . . .



FIGURE 6: Broadband, circularly polarized horn developed by Electronic Specialty has an H-plane beamwidth of 120 deg over a 1.6: bandwidth.

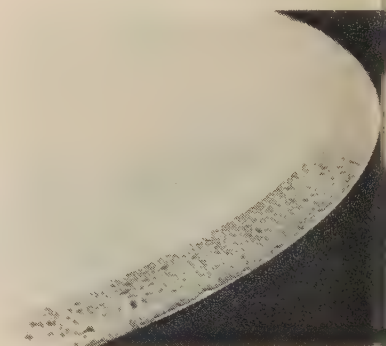


FIGURE 7: Double-slab-dielectric circularly polarized antenna.

It can be designed to operate efficiently over bandwidths of 10:1, radiates a beam along the axis of the spiral, which is circularly polarized. The width of the radiated beam is 60-80 deg over the bandwidth. Spiral antennas are mounted in a cavity. (See *S/A "Spiral Antennas Meet Needs of New Vehicles," Jan. '59, p. 56.*)

Surface-wave antenna is good for ECM

The surface-wave antenna is ideally suited for a number of ECM applications, for it has a reasonably wide bandwidth of operation and is light and easy to build. It propagates a wave that travels at less than the speed of light. Surface-wave antennas confine the radiation along the structure and radiate in an end-fire direction.

The surface-wave antenna consists of corrugated or dielectric

more on page 1

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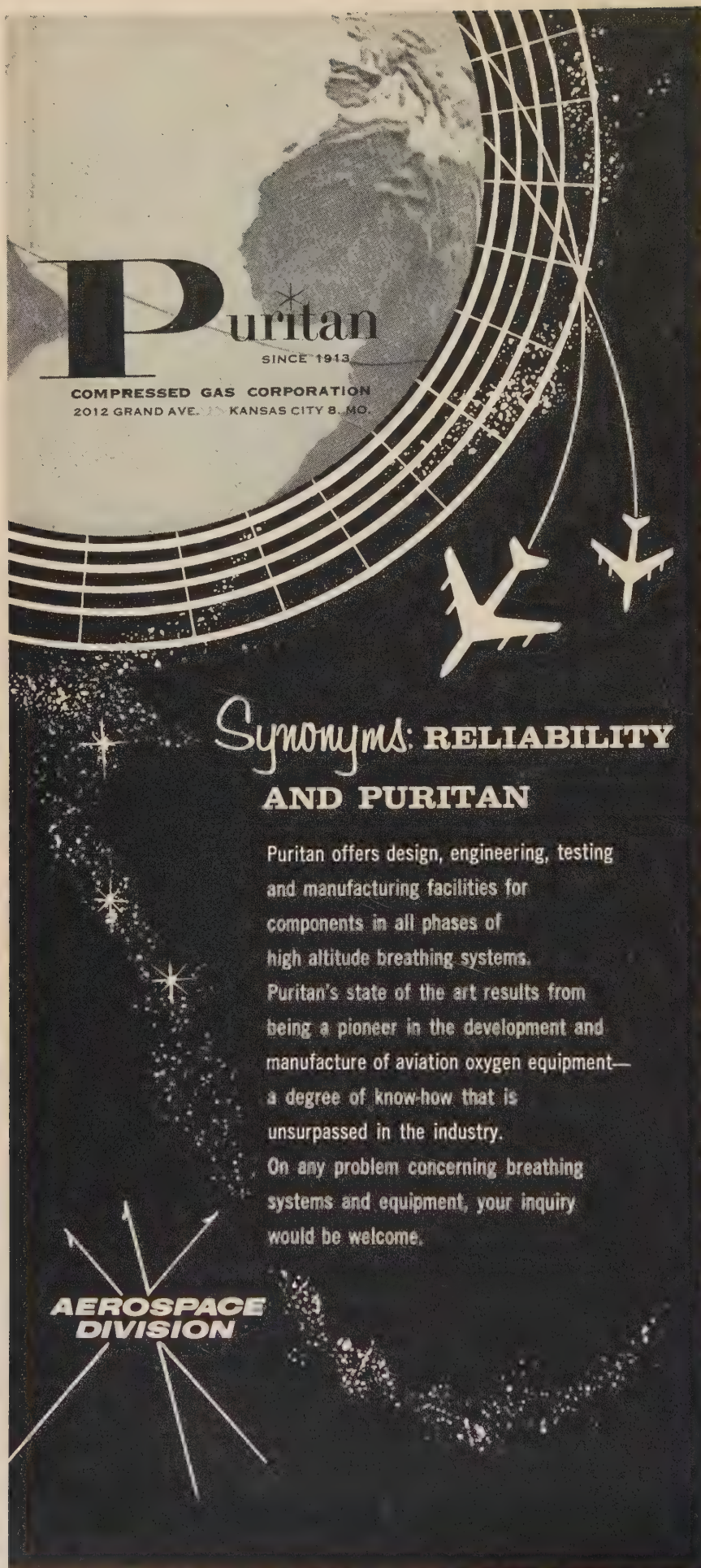


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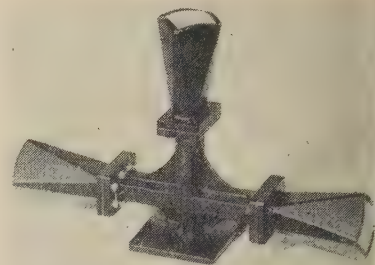


FIGURE 8: Antenna arrays like this circularly polarized one permit "looking" in discrete sectors.



HORN ANTENNAS are easily adapted to circular or variable polarization.

metallic surfaces. Either vertical or horizontal polarization may be supported by using either a dielectric consisting of two layers with different dielectric constants (Fig. 7) or a combination of dielectric and corrugated surfaces.

How to "look" in discrete angular sectors

In many ECM applications, it is desirable to "look" in discrete angular sectors. For this purpose, an array of elements is used with appropriate switching devices (Fig. 8). A good array meets two requirements:

- It covers a maximum bandwidth spectrum.
- It is of minimum weight and size and needs only a minimum radome if internally mounted.

The resulting radiation pattern is near-optimum, considering mounting position and external stores. The composite antennas are matched through power division transformation to minimize power loss and VSWR.

more on page 14



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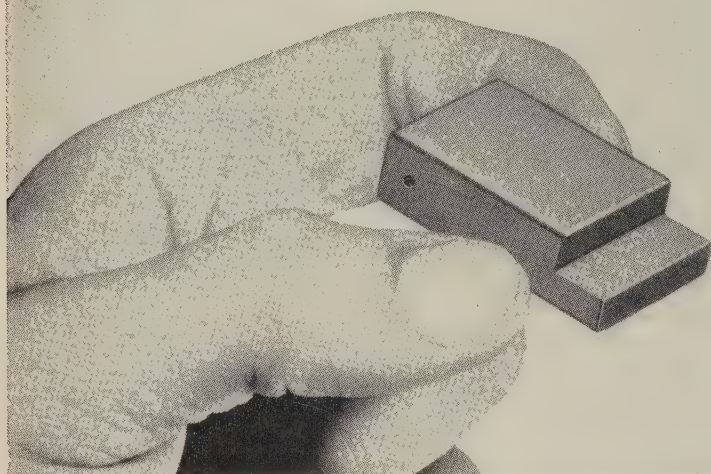
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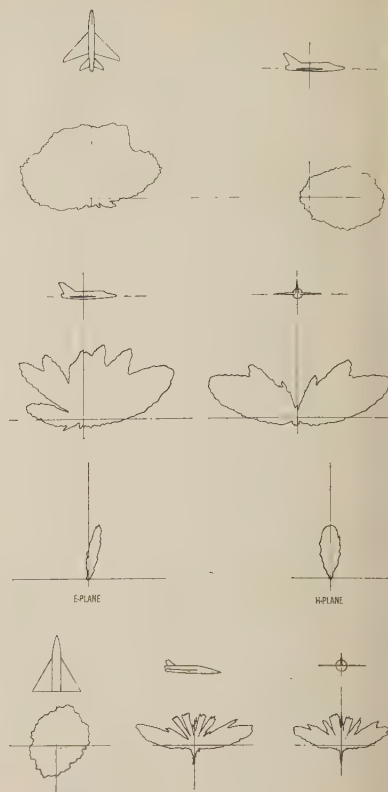
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ECM ANTENNAS . . .



RADIATION patterns of (top to bottom) circularly polarized broad-beam horn, hatchet, vertically polarized leaky-wave, and circularly polarized omnidirectional horn antennas (in the principal plane except as noted).

Directional ECM antennas with high gain are expected for the future—provided beam-swinging techniques giving response times in the 10-100-millimicrosec range can be developed. Such antennas would consist of arrays of small horns or other low-gain elements and would operate somewhat like the Van Atta array—sending a wave front back in the direction from which the received signal originated. With instantaneous directional ECM antenna systems, the effective delivered jamming power can be increased 10-100 times above present values.—End

Reprint Reminder

If you liked this special report and are ordering a reprint, perhaps you should check whether you don't want to get a reprint of *SPACE/AERONAUTICS'* special report on *Undersea Weapon Systems*, too. This report appeared in the January 1960 issue, and, judging from the reader response to date, we weren't bragging when we said that it brought more undersea information together than had ever before been combined in a single package.

Write in No. 309 on Reader Service Card at start of Product Preview Section



TODAY the aerospace industry is squarely confronted with a situation that cannot be soft-pedaled. Buying fasteners on the basis of price alone can be—and with sickening frequency is—disastrous. “But it met the specifications” is a feeble excuse in the face of a huge pile of smoldering scrap metal—the result of failure by a supposedly high-strength bolt. Yet the lot which included this bolt actually met specifications.

Still the bolt failed. Why? Was it improper manufacturing? Or weak quality control? Maybe careless testing. Or no testing at all. One thing, however, is certain, dead certain. Specifications alone cannot guarantee high reliability.

Aircraft, missile and rocket projects are far too critical to permit the assumption that a fastener will perform faultlessly simply because it meets the specifications.

Today the complete facilities of every fastener manufacturer must be uncompromisingly appraised, for his methods and equipment are the only assurance of the reliability of his product.

How to judge the reliability of different brand bolts? Take a good hard look at what stands behind each product.

Scrutinize. Probe. Compare.

Above all, note very carefully a supplier's ability to test fasteners. Does each manufacturer have all of the complex and powerful machinery that is absolutely essential to destructive testing of high-strength bolts? What about test results? Is the evidence really conclusive? To produce fasteners that will not fail, a manufacturer must test ceaselessly . . . ruthlessly.

Many in sensitive positions in the aerospace industry today are so often urged to keep their eye on “the big picture” that they may lose sight of *the small part*. Yet the deceptively simple aircraft bolt is a hotbed of surface and internal stresses. And, ironically, though it represents so minute a fraction of the project's cost as to be almost immeasurable, one fastener *can* cause catastrophe.

AIRCRAFT / MISSILE Division

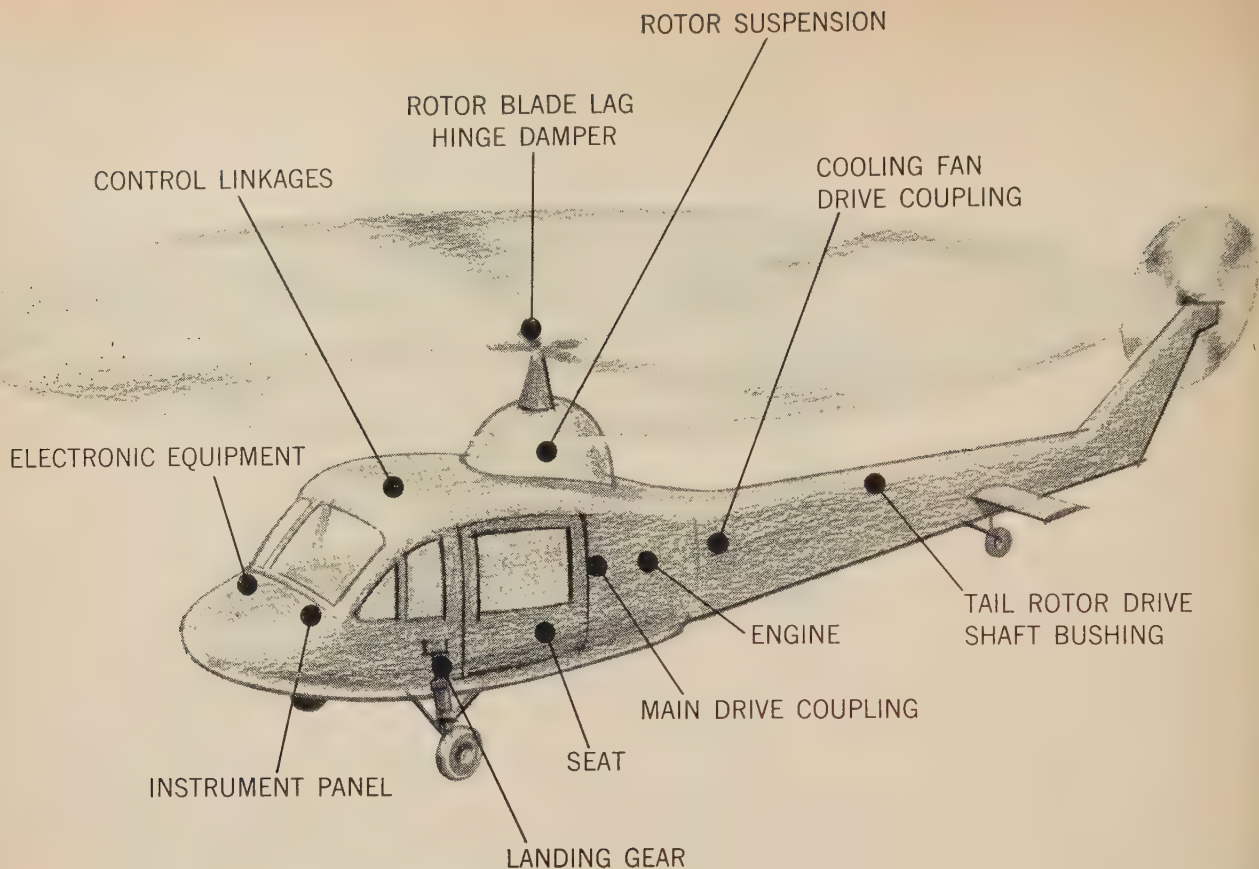
JENKINTOWN 54, PENNSYLVANIA

SPS WESTERN, SANTA ANA, CALIFORNIA

SPS

where reliability replaces probability

Write in No. 310 on Reader Service Card at start of Product Preview Section



critical points for *vibration/shock/noise* control

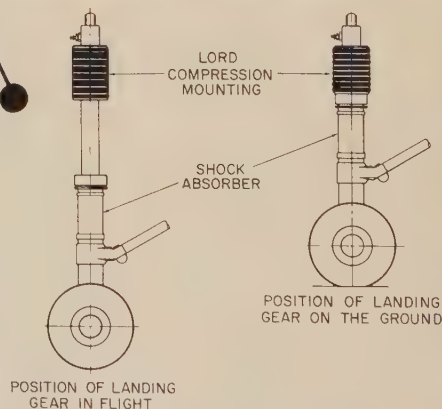
Improved flight characteristics, less noise and increased service life are major design objectives of helicopter engineers. LORD offers maximum assistance through advanced vibration/shock/noise control techniques and superior materials.

At critical points, LORD elastomeric mountings combat the undesirable effects of engine vibration, rotor disturbances, unbalance, taxiing shocks, operational noise, shaft misalignment and blade bottoming.

Close teamwork between helicopter engineers and LORD results in vital "breakthroughs" in cost, size, weight or service life. For example, an elastomeric rotor blade lag hinge damper provides improved performance with substantial savings in cost and weight.

Utilize LORD capabilities in vibration/shock/noise control to implement your helicopter, VTOL, STOL or convertiplane project. LORD experience plus modern facilities for research, custom engineering, production, and testing will assure an optimum solution. Contact your nearest Lord Field Engineering Office or the Home Office, Erie, Pa.

ADVANCED MATERIALS PERMIT UNIQUE DESIGNS



The low temperature flexibility, oil resistance and excellent damping properties of Lord BTR® elastomer are utilized in new landing gear spring. BTR compression mounting absorbs peak energy on landings, then protects landing gear and fuselage during ground operations.

FIELD ENGINEERING OFFICES

ATLANTA, GEORGIA - Cedar 7-9247
 BOSTON, MASS. - Hancock 6-9135
 CHICAGO, ILL. - Michigan 2-6010
 DALLAS, TEXAS - Riverside 1-3392
 DAYTON, OHIO - Baldwin 4-0351
 DETROIT, MICH. - Diamond 1-4340

KANSAS CITY, MO. - Westport 1-0138
 LOS ANGELES, CAL. - Hollywood 4-7593
 NEW YORK, N. Y. - Circle 7-3326
 PHILADELPHIA, PA. - Pennypacker 5-3559
 SAN FRANCISCO, CAL. - EXbrook 7-6280
 WINTER PARK, FLA. - Midway 7-5501

"In Canada—Railway & Power Engineering Corporation Limited"

LORD MANUFACTURING COMPANY • ERIE, PA.

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LORD®

Industry capabilities

This listing is based primarily on a survey of more than 100 aerospace companies, universities, and government organizations, which were asked to list their contractual experience and capabilities in electronic warfare as well as relevant literature. A number of companies and universities are included on the basis of information obtained by SPACE/AERONAUTICS in personal interviews or of their participation in technical meetings concerned with electronic warfare. Companies from which no detailed information was obtained and universities are grouped in a separate section at the end of this listing as are government organizations.

Areas of specialization are shown for each company that provided this information as italicized entries immediately following the company's name and address according to the following key: ER—electronic recon, A—active electronic countermeasures, P—passive electronic countermeasures, Ant — antennas.

A

AIRBORNE INSTRUMENTS LABORATORY, DIV., CUTLER-HAMMER, INC., Mineola, N. Y.—ER, A, P

• **CONTRACTS** — Team manager: USAF AN/USD-7 aerial recon system.

• **CAPABILITIES** — Feasibility and design studies on recon and surveillance; ECM and ECCM systems; recon receivers; vulnerability studies.

APPLIED TECHNOLOGY, INC., 930 Industrial Ave., Palo Alto, Calif.—ER, A

The bold-faced numbers given with the literature entries refer to the Reader Service Card opposite page 227. With this Card, you can easily obtain any of the offered literature.

Every effort, of course, was made to make the survey on which most of this listing is based as comprehensive as possible. However, because of the almost complete lack of references in the field of electronic warfare, the possibility of unwitting omissions cannot be ruled out. Companies that believe they have been incorrectly omitted from this listing therefore are invited to submit information on their recent contracts and their capabilities in electronic warfare (recon, countermeasures, and counter-counter-countermeasures) for inclusion in the reprint version of this listing. Such information should be addressed to Reprint Dept., SPACE/AERONAUTICS, 205 E. 42nd St., New York 17, N.Y., and must be in our hands by April 29.

• **CONTRACTS**—Development and fabrication of airborne microwave repeater-jammer using traveling-wave tubes to amplify signal from radar and deception techniques; electronically tuned ground-based microwave recon receivers for 10-40 kmc.

• **CAPABILITIES** — Active ECM, ECCM, recon receiving techniques, radio astronomy.

AUTONETICS DIV., NORTH AMERICAN AVIATION, INC., Downey, Calif.—ER

• **CONTRACTS**—Electronic recon.

B

BAIRD ASSOCIATES, Cambridge, Mass.

• **CONTRACTS** — Vulnerability studies on IR systems.

BJORKTEN LABORATORIES, Madison, Wis.—P

• **CONTRACTS** — Development of radar-absorbing materials.

• **CAPABILITIES** — Research and testing facilities.

C

COLLINS RADIO CO., TEXAS DIV., 1200 North Alma dr., Richardson, Texas—A, P, Ant

• **CONTRACTS**—Development and production of passive, microwave ECM receivers for surface and undersea craft; development of mobile ground ECM systems (active and passive techniques) in VHF range; mobile ground passive ECM system in HF range; production of airborne passive ECM receiver.

• **CAPABILITIES**—R&D of active and passive ECM and ECCM systems for ground, airborne, surface, and undersea environments; development of electro mechanical, electronic, and digital-tuned and programed receiving systems; system development in signal analysis and recording and system memory capability; direction finders; broadband ECM antenna systems.

CONVAIR DIV., GENERAL DYNAMICS CORP., San Diego 12, Calif.—E, A, P, Ant

• **CONTRACTS**—B-58 airborne electronic countermeasures; Terrier guided missile ECCM study and experimentation; APS-60 and ASB-12 airborne radars (Ku-band, active), ground passive electronics recon facility (microwave); Alice radar (ground-based, active, microwave); radar signature research (ground-based and airborne, active, microwave).

• **CAPABILITIES** — Microwave

more on page 184



What can you do with a remarkable instrument like this?

We knew we had an outstanding instrument in our product line when this readout device was introduced several years ago. It proved to be ahead of its time during those early days, but now this remarkable precision instrument for displaying data is gaining acceptance in many industries. It's about as big as a candy bar, and it will display, store, or transfer up to 64 different numbers, letters, or symbols without using complicated conversion equipment and "black boxes."

This is an entirely new species of readout device so we had to give it a new name, the Readall* readout instrument.

We developed the Readall instrument for data display in flight control equipment. We knew the Readall instrument was fine but didn't know just *how* valuable it was. But one of our engineers did. He designed a complete new pipeline control system based on the new instrument. The application was a breakthrough in data handling, and the control system is a big success.

Naturally, we put the Readall instrument

on the market so systems engineers could use it to improve their control systems. We announced the Readall instrument as "... an electro-mechanical, D.C. operated, readout device for displaying characters in accordance with a pre-determined binary code ... a compact, self-contained device ... which can be applied to the output of digital computers, teletype receiving equipment, telemetering systems, or wherever data must be displayed."

Other systems have been developed with separate units for data display, decoding, storing, and electrical readout. These separate units cost more and occupy more room. Market response confirms the need for *one, small*, inexpensive unit that does all three jobs. The Readall instrument serves the purpose.

We'd like to discuss possible applications for the Readall instrument with you. If you want information as to possible applications you have in mind for this remarkable instrument, please fill in the coupon.

**Trademark*

"Pioneers in Push-Button Science"



UNION SWITCH & SIGNAL

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PITTSBURGH 18, PENNSYLVANIA

Union Switch & Signal
Division of Westinghouse Air Brake Company
Pittsburgh 18, Pennsylvania

ATT: ADV. DEPT.

Here is a possible application we have in mind for the Readall instrument:

☐ Send more information about the Readall instrument

Name _____ Title _____

Company _____

Address _____

City _____ Zone _____ State _____

Write in No. 311 on Reader Service Card at start of Product Preview Section

CAPABILITIES . . .

components and circuits; airborne antennas; ground-based antennas; infrared optics; radomes (rigid and inflatable); radar cross-section studies; radar displays, transponders, transducer; terrain avoidance techniques; data handling and processing.

• **ECM LITERATURE** — Convair San Diego Electronics brochure #ZR-759-025 (No. **100** on Card); BANA brochure #ZR-759-027 (No. **101** on Card); MARKAR brochure #ZN-3 (No. **102** on Card).

D

DOUGLAS AIRCRAFT CO. INC.
Santa Monica, Calif.—*ER, A, P*

• **CONTRACTS** — Study, development, and integration of airborne active and passive systems, coverage is in both.

• **CAPABILITIES** — Systems evaluation and development; operational analysis; lab and flight systems evaluation; antenna design; data handling system design; microwave calibration support facilities (up to 50 kmc).

E

ELECTRONIC SPECIALTY CO., 512 San Fernando Rd., Los Angeles 39, Calif.—*Ant*

• **CONTRACTS**—ECM pod for century-series aircraft; power dividers and switches for B-47 and B-52; scimitar antennas (general ECM use); jam-resistance air target fuze; wide-band radiating systems, including antennas, power divider switches, filters, etc., for bomber defense systems.

• **CAPABILITIES** — Evaluation of ECM and ECCM systems; design and development from 21 mc to 75 kmc; complete pattern range; flexible and rigid wave guides, matching units, and horns for all bands.

• **LITERATURE** — Catalog: Radiation Systems and Components (No. **103** on Card); brochures: Electronic Specialty Capabilities (No. **104** on Card), Systems Laboratories Division (No. **105** on Card).

EMERSON & CUMING, INC., Canton, Mass.—*P*

• **CONTRACTS**—R&D on non-reflecting and radar-absorbing materials; R&D; development and production of microwave lenses (Luneberg).

• **CAPABILITIES**—Radar reflectivity work, absorber and reflective device development; dielectric materials investigations and development.

• **LITERATURE**—Short-Form Catalog (No. **106** on Card); Eccosorb brochure (No. **107** on Card) Ecco Reflective brochure (No. **108** on Card); Dielectric Materials wall chart (No. **109** on Card).

EMERSON RADIO & PHONOGRAPHIC CORP., GOVERNMENT ELECTRONICS DIV., 14th & Coles Sts., Jersey City 2, N. J.—*A, P*

• **CONTRACTS**—Study of vulnerability and development of CCM techniques; evaluation and prototype models of airborne ECM systems; anti-jamming and FM/CW radar studies; complete ECCM study; tunable jammer; jammer.

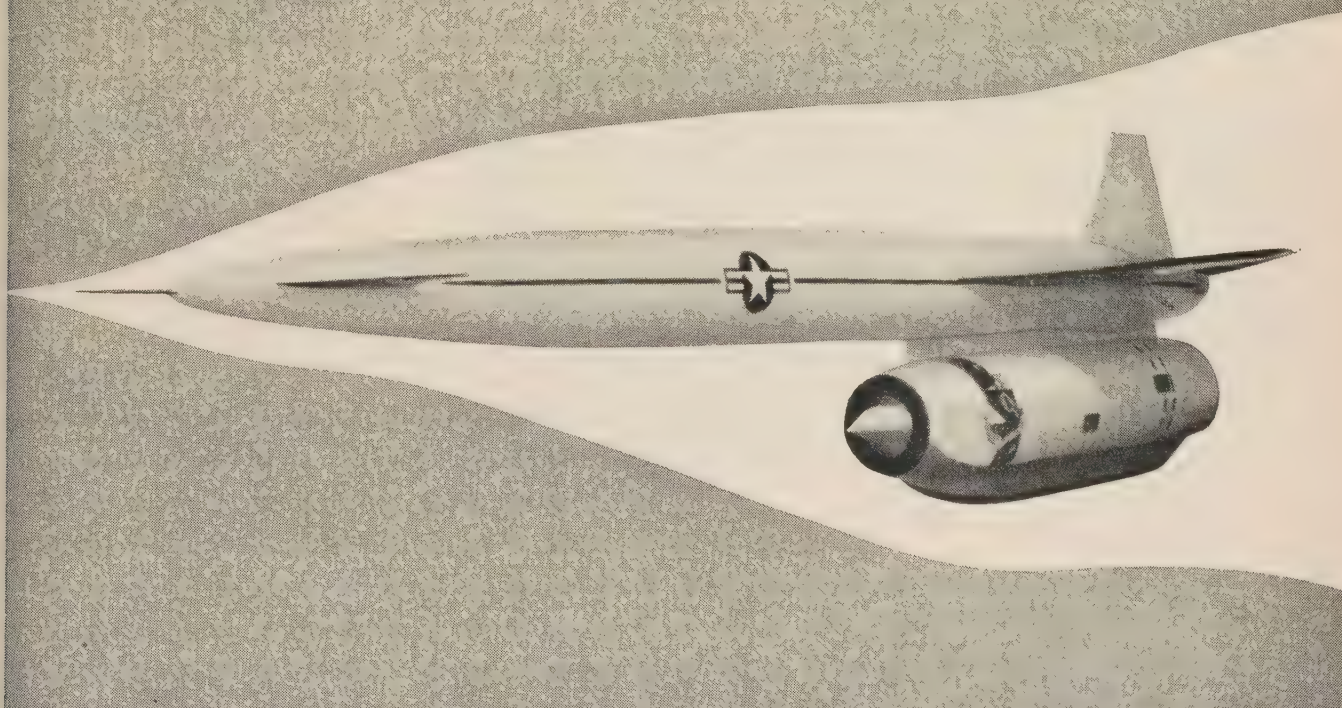
• **CAPABILITIES** — ECM and

more on page 18

Another Report
on Bendix



POWER
Capabilities



The GAM-77 "Hound Dog"—North American Aviation's Missile Division, prime contractor.
This air-to-surface missile is carried by heavy bombers of USAF's Strategic Air Command.

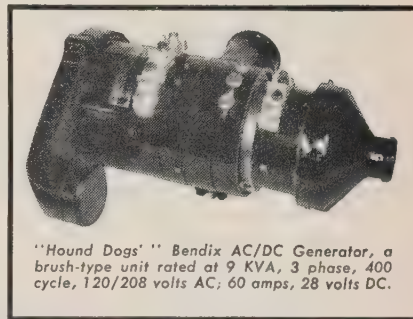
BENDIX AC/DC PACKAGE GENERATES DEPENDABLE IN-FLIGHT ELECTRICAL POWER FOR "HOUND DOG"

The "Hound Dog" missile adds still more reach and punch to SAC's long arm. Carried by a B-52 bomber, the missile can be launched several hundred miles away from the target, and is capable of delivering a nuclear payload.

Before launching, the missile's electrical needs are supplied by the mother ship. Once "Hound Dog" is on its own, a Bendix® AC/DC generator fully meets electrical power demands. In a great new

breakthrough in voltage control, the unit is equipped with a Bendix transistorized static AC/DC voltage regulator. The DC capacity of this Bendix AC/DC generator is provided with an addition of only five pounds in generator weight. Here is another example of the Bendix Red Bank concept of light-weight, reliable AC/DC power packages.

Get further details from RED BANK
GENERAL PRODUCTS DEPARTMENT.



"Hound Dogs" Bendix AC/DC Generator, a brush-type unit rated at 9 KVA, 3 phase, 400 cycle, 120/208 volts AC; 60 amps, 28 volts DC.

GENERAL PRODUCTS DEPARTMENT

Red Bank Division
EATONTOWN, NEW JERSEY



West Coast Office: 117 E. Providencia, Burbank, Calif.
Export Sales & Service: Bendix International, 205 E. 42nd St., New York 17, N. Y.
Canadian Affiliate: Aviation Electric, Ltd., P.O. Box 6102, Montreal, Quebec

Write in No. 312 on Reader Service Card at start of Product Preview Section

Du Pont "Pyrocore," a versatile string-type igniter, gives you uniform firing

Velocities to 21,000 ft./sec.: This "string" igniter (available in lengths up to 300 feet) is a flexible tube containing a detonating-ignition composition with which you can ignite a rocket propellant at velocities from 12,000 to 21,000 feet per second, depending upon type and amount of core composition selected.

"High speed" dependable ignition: In laboratory tests, "Pyrocore" reduced ignition time 99.5% when compared to a standard primer. Total ignition of a 21½" length of cannon primer was achieved in less than ¼ millisecond, as against 50 milliseconds required with a squib primer.

The stringlike form of "Pyrocore" gives you new freedom in design of rocket motors. For example, you can thread "Pyrocore" through jelly roll or basket type igniter assemblies, or string it around the propellant grains.

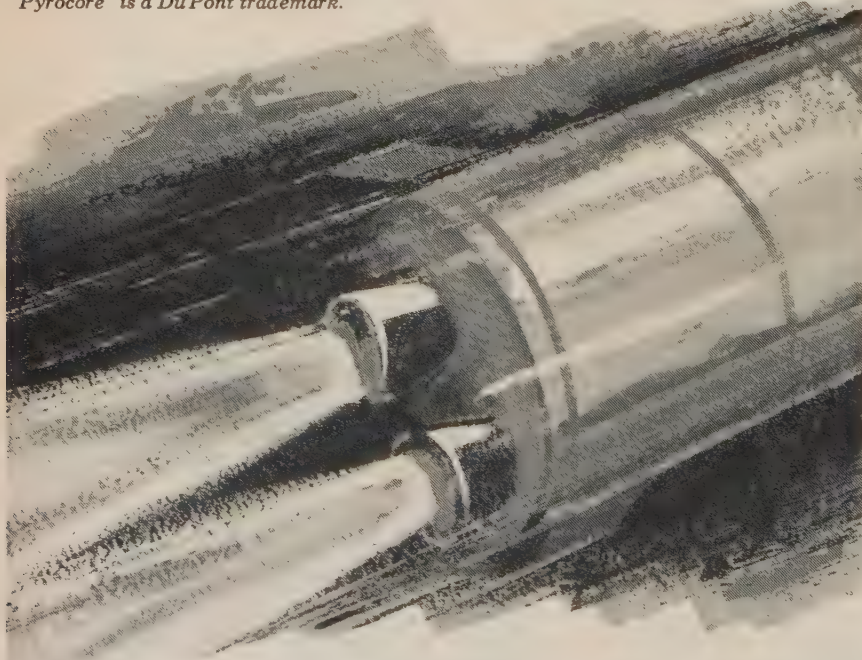
The versatility you obtain with "Pyrocore" results in the controlled simultaneous ignition of large surface areas of even relatively inert propellant grains.

Initiator assemblies may be located outside the propellant chamber, eliminating a major source of residue in the reaction zone. The "Pyrocore" itself detonates cleanly, leaves very little residue.

SAMPLE KIT AVAILABLE

"Pyrocore" igniter sample kit containing most standard types of "Pyrocore," and various end primers, initiators and accessories is available. Description and price of this kit will be sent if you write Du Pont, Explosives Department, 6539 Nemours Building, Wilmington 98, Delaware.

"Pyrocore" is a Du Pont trademark.



EXPLOSIVES

BETTER THINGS FOR BETTER LIVING...THROUGH CHEMISTRY

Write in No. 314 on Reader Service Card at start of Product Preview Section

CAPABILITIES . .

ECCM systems techniques, equipment development, and production.

• **LITERATURE** — Government Electronics Division brochure (No. 110 on Card).

G

GB ELECTRONICS CORP., Valley Stream, N. Y.—P, Ant

• **CONTRACTS** — Surveillance and tracking antennas.

• **CAPABILITIES** — Large ground-based antennas; passive DF systems.

GENERAL CERAMICS, Keasbey, N. J.—P

• **CONTRACTS**—R&D and production of radar-absorbing materials and coatings.

• **CAPABILITIES** — Lab measurements and testing for development of radar-absorbing materials.

GENERAL ELECTRIC CO., LIGHT MILITARY ELECTRONIC DEPT., Utica, N. Y.—ER, A, P

• **CONTRACTS**—Search receivers, ECM equipment, distance-measuring fuzes, anti-jamming circuitry, IFF, AN/APS-81 forward surveillance radar, AN/ARR-39 and -44 data links; AN/ALT-6B ECM equipment; advanced radar and data processing equipment for early-warning systems.

• **CAPABILITIES**—Lab measurements and testing in anti-jamming techniques; ECM and infrared techniques; study of operating environments; ECM simulation studies.

GENERAL MILLS, INC., 1620 Central Ave., Minneapolis 13, Minn.—A, P

• **CONTRACTS** — Advanced ECM simulators.

• **CAPABILITIES**—R&D and production on ECM simulation equipment; ECCM techniques, studies, and system vulnerability analysis.

GRANGER ASSOCIATES, 966 Commercial St., Palo Alto, Calif.—Ant

H

HALLICRAFTERS CO., 4401 West Fifth Ave., Chicago 24, Ill.—ER, A, P

• **CONTRACTS** — Airborne recon and ECM equipment between VHF and K-band; ground support equipment for testing and maintaining this equipment; management of USAF Quick Reaction Capability program.

• **CAPABILITIES** — Accelerated R&D and production of recon and ECM equipment.

• **LITERATURE**—General Production Catalog (No. 111 on Card).

HAZELTINE ELECTRONIC DIV., HAZELTINE CORP., 59-25 Little Neck Parkway, Little Neck, N. Y.—ER, A

• **CONTRACTS** — Airborne active microwave search radars, (AN/APS-81, AN/APS-95); ground active microwave recon radar (AN/TPS-25); airborne active microwave search radar (AN/APS-20); air-ground secondary IFF microwave identification radar (Mark XII).

• **CAPABILITIES** — Doppler tech

techniques; signal processing; satellite guidance.

HOFFMAN ELECTRONICS CORP., 3740 S. Grand Ave., Los Angeles 7, Calif.—A, P, ER

- **CONTRACTS**—R&D and production of ECM equipment and components; ECM receivers; electronic recon.

- **CAPABILITIES**—R&D in electronic recon and ECM; advanced receiver design and production; vulnerability studies.

HUGHES AIRCRAFT CO., MICROWAVE LABORATORY, Culver City, Calif.—Ant

- **CONTRACTS**—R&D on fire control early warning, recon, and communications antennas; studies of low-sidelobe-level antennas; design and production of electronically scanned antennas; filters; passive and active ferrite devices; isolation duplexers, switches, phase shifters.

- **CAPABILITIES**—Microwave research; studies of low frequency and microwave active circuits; advanced receiver techniques; superconductivity studies; traveling-wave tube oscillator circuitry; monopulse tracking; special receiver problems.

- **LITERATURE**—Microwave Engineering bulletins (No. 112 on Card).

INTERCONTINENTAL ELECTRONICS CORP., 1551 Franklin Ave., Mineola, N. Y.

- **CONTRACTS**—Triple frequency diversity radar (AF); scan conversion system (AF Rapcon Program); Spanrad system (Navy).

- **CAPABILITIES**—Frequency diversity radar; display systems.

- **LITERATURE**—Diversity Radar report (No. 113 on Card); TMA 403X technical specs (No. 114 on Card); TI-440 Scan Converter brochure (No. 115 on Card).

INSTRUMENTS FOR INDUSTRY, INC., Hicksville, N. Y.—A, P

- **CONTRACTS**—Emphasis on VHF and UHF equipment for communications and VT fuze jamming (AN/TLO-4, AN/MLQ-8(XE-2), AN/TLO-14 Manpack ECM systems; AN/TLO-11 VHF-UHF receiver).

- **CAPABILITIES**—ECM R&D and production; emphasis on automatic wide-band ECM testing and research.

- **LITERATURE**—Company brochure (No. 116 on Card).

ITT LABORATORIES DIV., INTERNATIONAL TELEPHONE & TELEGRAPH CORP., 500 Washington Ave., Nutley, N.J.—ER, A, P

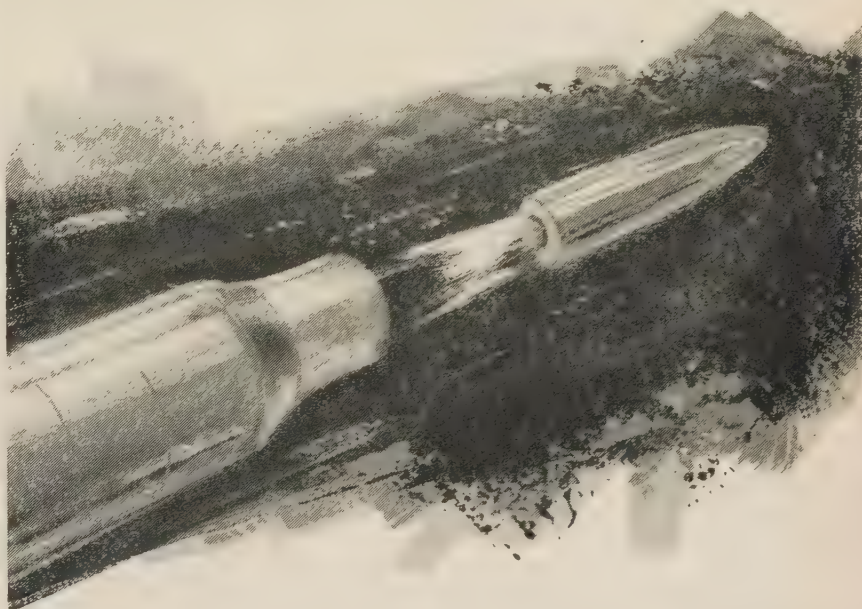
- **CONTRACTS**—Recon: electronic intelligence studies (microwave), detection techniques (airborne, microwave), ground-based electronic recon data computer; ECM: electronic defense evaluator (ground equipment), repeater scanning study and simulators (all frequencies).

- **CAPABILITIES**—Data handling; receiver design; electromagnetic propagation; ECM statistical analysis; data handling.

more on page 190

Du Pont "MDF" mild detonating fuse

"tiptoes" past sensitive equipment,
performs remote actuations, separations



Before MDF was developed, the mildest detonating fuse you could buy contained 30 grains of PETN per foot—too powerful to place near sensitive areas in your rocket design.

But today you can have detonating fuses containing core loads as low as 1 grain per foot—enough explosive power to *carry* a detonation from one point to another—but *not* enough to violently rupture its own plastic sheathing.

Thus you can use MDF to safely transfer a detonation *anywhere*, to perform such functions as separating, disconnecting, releasing switches, operating arming devices, opening hatches or initiating larger explosive charges.

You get *precise* transmission speeds: velocities range around 20,000 ft./sec. and can be controlled within $\pm 1\%$ for a given core size. MDF is extremely reliable; approximately 1 million feet were used in one specific application without failure.

Strength, velocity and temperature resistance can be varied over generous ranges, and many types of tubing can be provided, including metal, plastics, wires and textiles to overcome problems of abrasion, corrosion, damaging effect and noise control.

Sample Kit Available

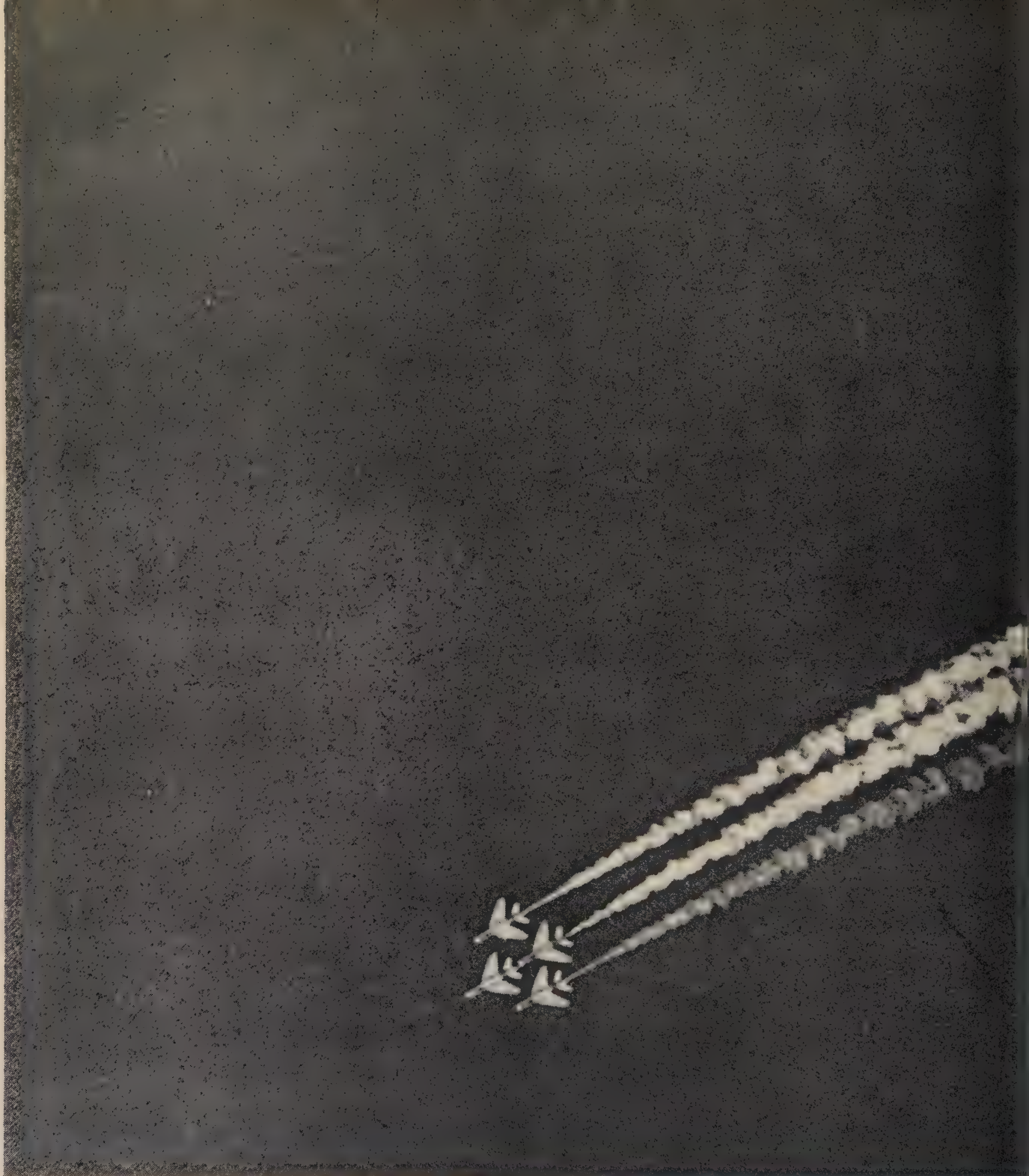
MDF sample kit, containing most standard types of MDF and various end primers and initiators, plus other accessories, is available. Description and price of this kit will be sent if you write Du Pont, Explosives Department, 6539 Nemours Building, Wilmington 98, Delaware.



EXPLOSIVES

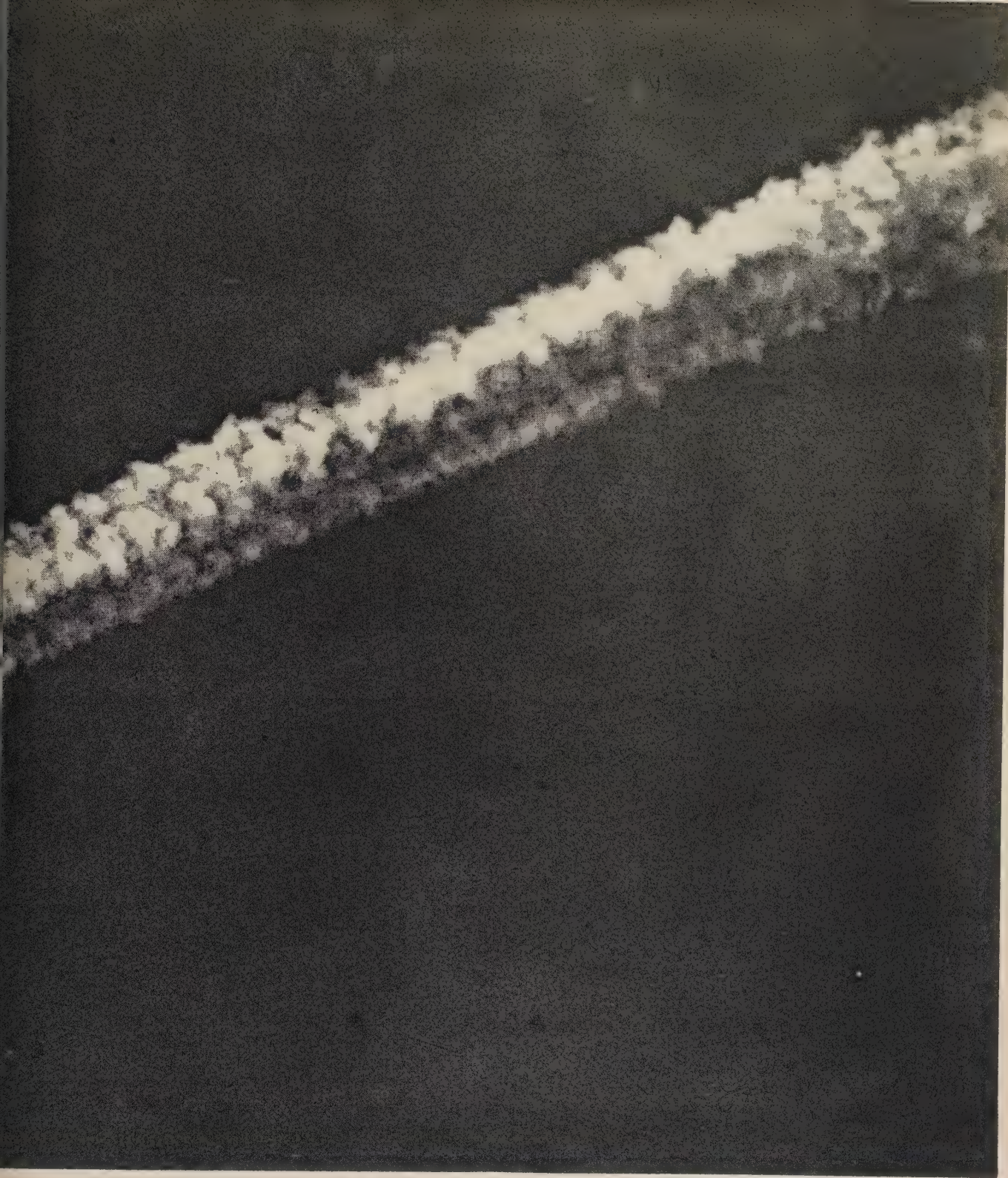
BETTER THINGS FOR BETTER LIVING...THROUGH CHEMISTRY

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electrical energy for the needs of motion

While the prime moving forces change as man moves his vehicles from the highway to the sky and on into space, the all-important auxiliary power continues to be electricity. Jet, rocket and missile contractors who are in need of reliable units for the accurate release, transformation and control of vital electric energy can turn to Delco-Remy for certain on-time delivery, whether the quantity be measured in tens or ten thousands.



Why? Because Delco-Remy electrical systems have proved their dependability for half a century. Because new concepts and new techniques have been evolved as our Applied Science and Electrochemical Research Departments continually meet new challenges. Because we have the tools for research, for testing, for production—the talents of outstanding physicists, chemists and engineers—and the professional atmosphere in which they can flourish.

Delco-Remy's research and development program on electrical components of high reliability for advanced weapon systems currently includes • Sensors • Servo Systems • Power Sources • Power Generators and Converters • and Precision Miniature Relays

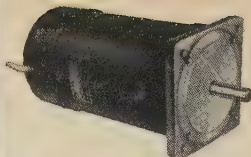
Delco-Remy

From the highway to the stars

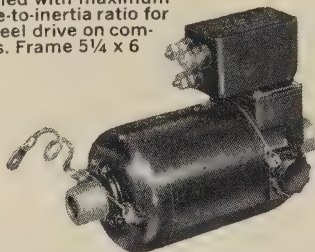
DIVISION OF GENERAL MOTORS, ANDERSON, INDIANA

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AVENUE TO THE RIGHT MOTOR...



110 Volt DC servo motor designed with maximum torque-to-inertia ratio for tape reel drive on computers. Frame 5 1/4 x 6



24 Volt DC aircraft motor for windshield wiper drive. Includes radio interference filter. Frame 2 1/2 x 1 1/2



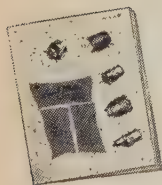
Totally enclosed submersible 24 volt DC motor for tank ventilating fan drive. Frame 5 x 2 1/4

Rigid and detailed testing assure desired performance

Thorough study by our engineering department of your product and its operating conditions enables us to design a Lamb® motor that will meet your exact requirements.

After rigid and detailed testing, we then mass produce the motor to obtain the most favorable cost.

May we discuss these advantages of Lamb motors with you?



WRITE FOR YOUR COPY...

8-page folder describes these and other Lamb Electric motors.

Lamb Electric SPECIAL APPLICATION FRACTIONAL HORSEPOWER MOTORS

THE LAMB ELECTRIC COMPANY • KENT, OHIO

A Division of American Machine and Metals, Inc.

In Canada: Lamb Electric —
Division of Sangamo Company Ltd. — Leaside, Ontario

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The Aeronautical Group

A. V. ROE CANADA LIMITED

announces the opening of a U. S. Office

SUITE 121, 8921 SEPULVEDA BLVD., LOS ANGELES 45, CALIFORNIA

W. R. Stephens, Technical Sales Manager, is in charge, assisted by W. C. Walter and S. H. Allen, and will operate throughout the United States to present customers in the armed services and industry with the products and services of these companies.

AVRO AIRCRAFT LIMITED • CANADIAN APPLIED RESEARCH LTD.
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Inquiries invited

A. V. Roe Aeronautical Group Limited

SUITE 121, 8921 SEPULVEDA BLVD., LOS ANGELES 45, CALIFORNIA

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CAPABILITIES . . .

ding transmitter and receiver design; solid-state circuit design; display techniques.

• LITERATURE—ECM Simulator brochures (No. 117 on Card).

L

LITTON INDUSTRIES, INC., 336 N. Foothill Rd., Beverly Hills, Calif.—ER

• CONTRACTS—Electronic recon: airborne data processing, storage, display, and transmission; shipboard data processing and display equipment.

• CAPABILITIES—R&D on advanced airborne and ground data processing and display.

M

THE MARTIN CO., ELECTRONIC DIV., Baltimore 3, Md.—ER

• CONTRACTS—Recon system for technical intelligence; AN/ALD-1; recon system AN/ASQ 22-V; semi-automatic recon equipment; transistorized semi-automatic recon system.

• CAPABILITIES—R&D and production: receivers, analysis and display equipment, data processing equipment.

• LITERATURE — "Versatronics" (No. 118 on Card).

THE MARTIN CO., ORLANDO DIV., Fla.—ER, A, P, Ant

• CONTRACTS—ECM Systems related to Pershing SSM; Bullpup ASM, Lacrosse SSM, Missile Master air defense system, Bullpup ASM.

• CAPABILITIES — Communications, information theory, mathematics; facilities: analog and digital computers, RF lab, inertial guidance lab, antenna test ranges, environmental, dynamics, hydraulic, and electronics labs.

MELPAR, INC., Falls Church, Va.—ER, A, P, Ant

MISSOURI RESEARCH LABORATORIES, INC., 2109 Locust St., St. Louis 3, Mo.

• CONTRACTS—Model 313 and 413 radar analyzers; APS-23 radar indicators; prime for tracking and scanning equipment R&D; subcontracts with Bell Aircraft, GE, Motorola, Lockheed, Western Electric.


• CAPABILITIES—Radar checkout systems; display systems; radar ECM analyzers.

• LITERATURE—Product brochure (No. 119 on Card); Model 313 brochure (No. 120 on Card).

MOTOROLA INC., MILITARY ELECTRONICS DIV., 8201 E. McDowell Rd., Scottsdale, Ariz.

• CONTRACTS—Recon; ARF (passive-active, VHF) and passive microwave target drone; ECM: ECM vs air operations studies, electronic warfare system analysis (passive-active, ground equipment, all bands), false-target techniques (Airborne, passive-active, microwave), AN/ALQ-17(XY-3)—airborne, passive-active, LF; ECCM: AN/MSG-4 (ground, microwave, passive); passive target seeker (airborne, microwave).

more on page 194



THE X-15: ACT ONE FOR MAN IN SPACE

As North American's X-15 — world's most advanced manned research craft—parts the curtain of earth's atmosphere, the arts of guidance and direction must play a critical role. Sperry's Air Armament Division, assigned the Flight Data System responsibility for the X-15, is meeting the challenge with inertial guidance gear of advanced design, precision and dependability.

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lyzed, tested, evaluated and understood inertial guidance system in being — plus the advanced guidance equipment for the X-15 and for other future applications.

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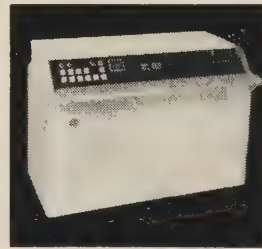
Wide range of applications: the RPC-4000 has been designed for engineering, scientific, business data processing and management control functions. Such jobs as product and process design, statistical analysis, research, inventory control, payroll and sales analysis are all well within its capabilities.

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Heart of the RPC-4000 system is a new transistorized computer with advanced design concepts that provide substantial computing speed and capacity in a low-cost unit. Magnetic memory drum stores **8008 words**. Operating speeds are as high as **230,000/minute**.

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A new 500 character/sec. photo-electric tape reader and a 300 character/sec. punch are available as optional input-output equipment. A magnetic tape unit and a line printer will be available soon. As many as 17 input-output devices (60 with minor modification) may be connected on-line to the basic system. All peripheral equipment is under automatic program control of the computer.



Royal Precision Corporation

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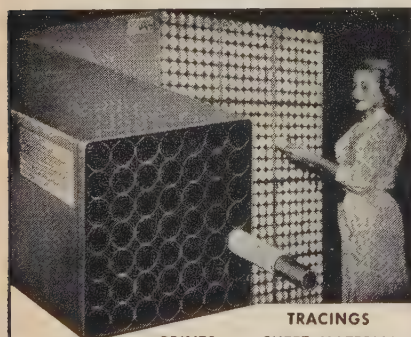
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CAPABILITIES . . .

- **CAPABILITIES**—R&D and production.
- **LITERATURE**—General company brochures (No. 121 on Card).

N

NORTRONICS DIV., NORTHROP CORP., 500 E. Orangethorpe Ave., Anaheim, Calif.

• **CONTRACTS**—AN/ALE-17: advanced forward-launch chaff dispensing set; ECM subsystem for B-52; physical counter-measures for airborne defense systems (devices and techniques to deceive enemy radar, particularly forward-launch chaff and infrared flares and force-ejected chaff).

• **CAPABILITIES**—Weapons system analysis, design and test, fuze design, heat transfer, mechanisms and vehicle design, pyrotechnics, solid-state physics, and wave propagation; R&D labs, experimental and test areas, static firing facility.

• **LITERATURE**—Physical Counter-measures—NSS Report 582 (No. 122 on Card).

P

PICKARD & BURNS, INC., Needham, Mass.—Ant

• **CONTRACTS**—Rotating DF radar antenna (horizontally and vertically polarized horns, directional dipole); circularly polarized jamming antenna (30:1 band width, airborne or ground use); two airborne radar systems for use in training and as ECM generators.

• **CAPABILITIES**—Fixed or portable direction-finding antenna systems; airborne surveillance radar; special broadband jamming antennas; flexible microwave generators.

• **LITERATURE**—Technical project summaries booklet (No. 123 on Card).

PLANNING RESEARCH CORP., 1333 Westwood Blvd., Los Angeles 24, Calif.

• **CONTRACTS**—Recon: production of models of intelligence target structures for evaluation of advanced recon systems; studies of space and orbital recon operation, development of tactical system requirements for acquisition of tactical field targets, studies of rapid-reaction tactical recon systems, studies of presentation and interpretation techniques for flash evaluation of data and attack of fleeting targets; countermeasures: studies of ECM threat to BMEWS (ground-based, airborne, active, and passive), ECM vulnerability studies of fire control and guidance for surface-to-air missiles, Active and passive ECM vulnerability studies for IRBM, studies of vulnerability of mobile and fixed Minuteman to active and passive ECM, studies reliability, vulnerability, and jamming of world-wide communication systems; ECCM: studies of relative effectiveness of pulsed and CW seekers for land-based Talos (emphasis on low-altitude ECM environment), studies of techniques and procedures for improving ECM resistance of BMEWS.

• **LITERATURE**—Company brochure (No. 124 on Card).

POLARAD ELECTRONICS CORP., 43-20 34th St., Long Island City 1, N.Y.
more on page 196

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• **CONTRACTS** — Channelized ground receiver; automatic test equipment for defensive B-58 ECM equipment; miniaturized modular intercept equipment (airborne-ground); miniature data handling system (ground); ground ECM receiving set AN/TLR-20.

• **CAPABILITIES**—Search and intercept receivers; data handling systems; ECM test equipment; ECCM receivers; ECM trainers and simulators; automatic checkout systems.

• **LITERATURE**—Facility report on ECM equipment (No. 125 on Card); company facility report (No. 126 on Card); instrument catalog (No. 127 on Card).

R

RADIATION, INC., Melbourne, Fla.—*ER, A, P, Ant*

• **CONTRACTS**—Recon: AN/SQR-7 shipboard, AN/TLR-11 ground UHF, Firefly (Scatter Study), ATIC studies, ECM: ECM antenna for AN/ALQ-27, airborne AN/ALE-9, chaff evaluation system, Operation "Tank Farm," airborne ECM antennas. ECCM: AJ for deceptive techniques; ECM-ECCM evaluation study; AN/USQ-23 (V) timing set (ground).

• **CAPABILITIES** — Telemetry systems for Minuteman, Holloman Rocket

Sled, etc.; studies in almost all U.S. bombers and missiles and most foreign aircraft; unique radar site for QRC and chaff evaluation; instrumentation: data processing, ground checkout, simulation, training, and GSE.

• **LITERATURE**—Radiation service (No. 128 on Card); Reflectivity Bulletin (No. 129 on Card); TLM-18 antenna brochure (No. 130 on Card).

RADIO CORP. OF AMERICA, Camden 2, N. J.—*ER, A, P, Ant*

• **CONTRACTS**—Systems for manned, unmanned, and extra-atmospheric vehicles; transmitting and receiving equipment, active defense systems, and simulators for heavy bombers and attack aircraft; development and production of ground and shipborne ECM equipment evaluation studies of specific threats to AF weapons; shipborne, ground and airborne radar systems and components.

• **CAPABILITIES** — ECCM and ground and shipborne ECM (passive and active); vulnerability analysis; R&D on integrated penetration projects, lunar, spatial, and orbital system ECM and ECCM.

RAMO-WOOLDRIDGE DIV., THOMPSON RAMO WOOLDRIDGE INC.,

8433 Fullbrook Ave., Canoga Park, Calif.

• **CONTRACTS**—Recon: AF 30 (602)-2038, AF 33 (600)-24212, 38627, 37394, sub to Boeing 7-40000-3-7600 (for USAF); ECM: AF 33(604)-16900, 22748, 26097, AF 29 (600)-1745, sub to MAC PO 7EO754R (for USAF); ECCM: AF 30 (602)-1687, 1880, AF 19(604)-5733, AF 33(616)-6218; NOBsr-77540, DA-36-039-SC75052, FAC PO 228-1.

• **CAPABILITIES** — Studies, R&D and production: large airborne offensive ECM systems (active and passive) throughout radar frequency ranges; studies of ECM vulnerability of infrared; airborne and surface ECCM systems for detection, direction-finding, tracking, signal location, and immunization of radar (passive and active, radio and radar frequency range); electronic recon systems for data collection, storage, automatic processing, and display (radio, radar, and IR frequency ranges) for air, space, and ground use.

RAYTHEON CO., Waltham, Mass.—*ER, A, P, Ant*

• **CONTRACTS**—Prime contracts in many areas involving ECM and particularly ECCM; ground and shipborne tracking surveillance radar, ECM re-



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- **CAPABILITIES** — Advanced ECCM for ICBM early-warning and defense systems; extensive microwave components lab; space ECM research; advanced ECM antenna R&D; system vulnerability studies.

REPUBLIC AVIATION CORP., MISSILE SYSTEMS DIV., 223 Jericho Turnpike, Mineola, N.Y.—*ER, A, P*

- **CONTRACTS** — R&D for advanced ballistic missile defense systems involving decoy discrimination and target destruction.

- **CAPABILITIES**—R&D on electronic recon and decoy discrimination; active and passive ECM techniques.

S

SANDERS ASSOCIATES, INC., Nashua, N.H.—*A, P, Ant*

- **CONTRACTS**—Design and development of receiving equipment in Plato detection system; production of radar antennas and microwave equipments; research in ECM and ECCM techniques.

- **CAPABILITIES**—Research in missile guidance Panar radar ECM equipment and anti-jam techniques; production of missile components, antennas and microwave equipment, and receivers.

SERVO CORP. OF AMERICA, Mineola, N.Y.—*P, Ant*

- **CONTRACTS** — Direction-finding equipment; infrared R&D; studies of instantaneous direction-finding for counter-submarine measures.

- **CAPABILITIES**—R&D and production of DF equipment; infrared development lab.

SPERRY GYROSCOPE CO., COUNTERMEASURES DIV., Great Neck, N.Y.—*ER, A, P, Ant*

- **CONTRACTS**—AN/ALQ-27 prototype production programs for integrated airborne ECM system; AN/ALQ-5 development; AN/USD-7 test equipment; automatic jamming system study.

- **CAPABILITIES**—Advanced development engineering in new ECM techniques; management of large electronic weapon systems; production of complex electronic equipment.

STAVID DIV., LOCKHEED ELECTRONICS CO., Rte. 22, Plainfield, N.J.

- **CONTRACTS**—Study of ECM vulnerability of IFF and similar systems and vulnerability study of Mark XII IFF (emphasis on air-by-ground IFF systems, involved operations analysis of systems, including mathematical studies, lab tests,

and construction of special test equipments).

- **CAPABILITIES**—Spectrum analysis; vulnerability studies; matched filter techniques; antenna development (UHF and VHF).

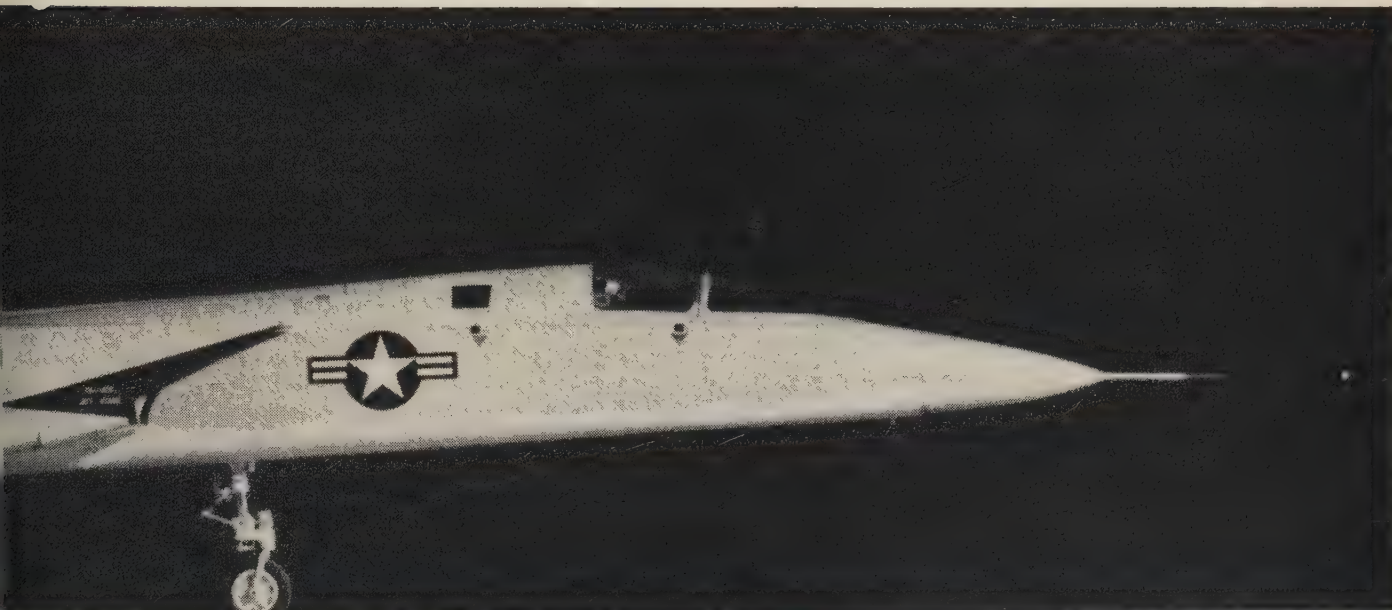
STROMBERG-CARLSON DIV., GENERAL DYNAMICS CORP., 100 Carlson Rd., Rochester 3, N.Y.—*ER*

- **CONTRACTS**—"Adding Security to the Tacan System;" jamming "vulnerability study of Tacan system; Vocoder and Multiplex; communications security system; crystal video intercept receivers; systems manager for AF Ground Passive Electronic Reconnaissance Facility.

- **CAPABILITIES**—Electronic warfare systems management and design; missile range radio frequency monitoring and interference control systems; intercept receivers (manual, panoramic, and signal-see); multi-function antennas; high speed photographic recording; data processing and high speed readout; high-speed solid-state switching.

- **LITERATURE** — Intelligence systems management (No. 131 on Card); intercept receivers (No. 132 on Card); displays (No. 133 on Card); high speed readout (No. 134 on Card).

more on next page



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CAPABILITIES . . .

SYLVANIA ELECTRIC PRODUCTS, INC., Waltham, Mass.—ER, A, P, Ant

- ECM CONTRACTS—Prime and weapon system manager on Plato; prime for B-58 "electronic shield;" data processing phase of BMEWS; R&D and production for ECM and ECCM equipment and electronic recon.

- CAPABILITIES—R&D and production in ECM, ECCM, data processing, radar, communications, and antenna systems.

T

TAMAR ELECTRONICS, INC., 2045 W. Rosecrans Ave., Gardena, Calif.—ER, A, Ant

- CONTRACTS—B-47 antenna systems (active ECM, P-, L-, S-, C-, and X-band systems); Wex Val modification and test series (B-66 active ECM, ECCM and recon, P-, L-, S-, C-, and X-band systems); infrared detection study; airborne beacon antenna and beacon check-out systems (X-band beacon).

- CAPABILITIES—Active ECM antenna systems and components; environment Test Lab-Chamber (to 100,000 ft altitude, power factors to 700 W); electronic warfare system management.

- LITERATURE—"A New Concept in Weapons Systems Management" (No. 135 on Card).

TEMCO ELECTRONIC DIV., TEMCO AIRCRAFT CORP., P. O. Box 6191, Dallas 22, Texas—ER

- CONTRACTS—R&D on recon systems and components; development and manufacture of video correlator (passive ECCM device, ground and airborne use).

- CAPABILITIES — Weapon system studies in electronic and communications intelligence and ECM; precision digital computers and timing devices; static power supplies; solid-state modulators; augmentation devices; direction-finding systems; general receiver design; panoramic receiver design; broadband antenna design; radiation subsystem design; broadband distributed amplifier design; general instrumentation design.

- LITERATURE—"This is Temco Electronics" (No. 136 on Card).


V

VITRO LABORATORIES DIV., VITRO CORP., 200 Pleasant Valley Way, West Orange, N.J.

- CONTRACTS — Development of jamming effectiveness evaluation equipment (ground-based); development of support equipment for jamming effectiveness evaluation (ground-based); development of AN GLQ-7 and AN GPA(90) ECM effectiveness evaluation system (ground-based); development of monitoring and data processing equipment for ECM test support (ground-based); manufacture of data processing equipment for ECM test equipment (ground-based); engineering study of airborne performance monitors for ECM effectiveness.

- CAPABILITIES—Research, system and equipment development, production of data handling portions of systems; statistical and mathematical analyses; operations research; system effectiveness studies; systems engineering.

more on page 200



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CAPABILITIES . . .

VOUGHT ELECTRONICS DIV., CHANCE VOUGHT AIRCRAFT, INC., Dallas, Texas—*Ant*

- **CONTRACTS**—ECCM coders, decoders, and beacons; ECM antennas.
- **ECM CAPABILITIES** — Development and production of video correlators; general broadband antenna design.
- **LITERATURE** — Antenna brochure (No. 137 on Card); Capabilities brochure (No. 138 on Card).

W

WESTINGHOUSE ELECTRIC CORP., AIR ARM DIV., P. O. Box 746, Baltimore 3, Md.—*ER*

- **CONTRACTS**—ECM: B-70 defensive ECM systems, aerodynamic decoy, passive intercept system airborne jammer, study of defense of large naval aircraft; Recon: molecular engineering; 132A Bomber Defense Systems (AF); ECCM: development of Aero 13 fire control system, Aero 21-B bomber defense system, Bomarc seeker, AN/APQ-72 fire control radar; pulse Doppler AJ techniques.

- **CAPABILITIES**—ECM: broadband devices, digital system controller, high power broadband microwave amplifier, advanced filter techniques, high power broadband antennas; ECCM: anti-jam circuitry; recon: system synthesis and control, data processing.

Military Organizations

DEPARTMENT OF DEFENSE, Washington 25, D. C.

- Office of Director of Research & Engineering, Advisory Group on Electronic Warfare (working panels being formed on: electronic recon; test and evaluation; electronic systems; propagation; radiators and antennas; sensors and data processing and display; jamming, deception, and vulnerability; ECCM techniques).

AIR FORCE

- Air Research & Development Command, Andrews AFB, Md., Electronic Countermeasures Branch and Electronic Counter-Countermeasures Branch (ground-based ECM).

- Wright Air Development Div. Wright-Patterson AFB, Ohio—Aerial Reconnaissance Laboratory; Weapons Guidance Laboratory (airborne ECM and ECCM); Weapons Defense Div.; Electronics Defense Branch (airborne).

- Rome Air Development Center, Rome, N. Y., Electronic Warfare Laboratory (ground-based ECM);

- Air Force Cambridge Research Center, Cambridge, Mass., Electronic Research Directorate (basic research in ground-based ECM, ECCM, infrared, recon).

ARMY

- Chief of Ordnance: (1) Aberdeen Proving Grounds, Aberdeen, Md.; (2) Army Ordnance Missile Command (Redstone Arsenal, Huntsville, Ala., and White Sands Missile Range, White Sands, N. M.).

- Signal Corps: (1) Research and Development Laboratories, Ft. Monmouth, N. J.; (2) Electronic Proving Grounds, Ft. Huachuca, Ariz.

NAVY, Washington 25, D. C.

- Office of Chief of Naval Operations: (1) Deputy CNO, Air—Aviation Plans Div. (2) Deputy DNO, Flight Operations, Readiness—Surface Warfare Div.

- Bureau of Ships, Electronic Div., Electronic Warfare & Parts Section.

- Bureau of Naval Weapons, Office of Systems Direction, Avionics Div., ECM Branch.

- Office of Naval Research, Electronic Warfare Groups.

- Naval Research Laboratories (basic research).

Other Companies and Universities

The following companies are known to be active in electronic warfare research and/or development:

AMERICAN ELECTRONIC LABORATORIES, 121 N. 7th St., Philadelphia 6, Pa.

CHICAGO U., Inst. for Systems Research, Museum of Sci. & Ind., Chicago 37, Ill.

CGS LABORATORIES, 391 Ludlow St., Stamford, Conn.

ALLEN B. DU MONT LABORATORIES, 750 Bloomfield Ave., Clifton, N. J.

GEORGIA INSTITUTE OF TECHNOLOGY, Atlanta, Ga.

GILFILLAN BROS., 1815 Venice Blvd., Los Angeles, Calif.

HALLER, RAYMOND & BROWN, INC., State College, Pa.

U. OF ILLINOIS, Urbana, Ill. (study program on direction finding in MF and HF range).

JOHNS HOPKINS U., Baltimore, Md.—ER, A, P

MASSACHUSETTS INSTITUTE OF TECHNOLOGY, Lincoln Laboratories, Bedford, Mass.

U. OF MICHIGAN, Ann Arbor, Mich.—ER, A, P, Ant

MINNEAPOLIS-HONEYWELL REGULATOR CO., 2747 4th Ave., S. Minneapolis, Minn.

NEW YORK U., Research Div., College of Engineering, University Heights, New York 53, N. Y.—P

OHIO STATE U., Columbus, Ohio—Ant

PHILCO CORP., Philadelphia 34, Pa.

PENNSYLVANIA STATE U. University Park, Pa.

POLYTECHNIC INSTITUTE OF BROOKLYN, 99 Livingston St., Brooklyn 1, N. Y.—P, ER, A

STANFORD U., Stanford, Calif., (microwave research)

SYRACUSE U., Syracuse, N. Y.

SYSTEMS, INC., Orlando, Fla.

U. OF TEXAS, Austin, Texas.



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Flexible temperature range -100° F TO 500° F

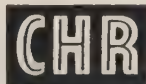
COHRLastic R-10470 silicone sponge rubber sheets have a dense, uniform, non-absorbing closed cell structure highly suitable for soft gasketing, vibration dampening, fairing strips, pads, cushions and other applications where resiliency at extreme temperatures is required. It may be bonded to metals, plastics, fabrics or silicone rubber. COHRLastic R-10470 possesses superior compression set resistance, excellent dielectric properties, immunity to aging, ozone and weather hardening.

COHRLastic R-10470 meets: AMS 3195; AMS 3196; Boeing BMS 1-23; Martin—MMS C451 and MB 6103; Scintilla 9-3143; Bendix ES-0709; Douglas DMS 1597; Lockheed LAC 1-924; Minneapolis Honeywell 6384-3 and Sperry Gyroscope P.691.764 Type HTM.

AVAILABLE FROM STOCK: in 12" x 12" sheets and 24" x 24" sheets — $\frac{1}{16}$ " through $\frac{1}{2}$ ". Special thicknesses and sheet sizes up to 30" x 30" and 24" x 48" can be made to order. COHRLastic R-10470 is sold nationally through distributors.

CHR PRODUCTS INCLUDE: Airframes and engine seals, firewall seals, and coated fabrics; Silicone rubber moldings and extrusions, silicone rubber sheets, silicone sponge rubber; silicone cements; conductive gasketing; and Temp-R-Tapes — pressure-sensitive, thermal curing Teflon* Fiberglas and silicone rubber tapes.

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OIL FILM
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#6 GAGE

#5

#4

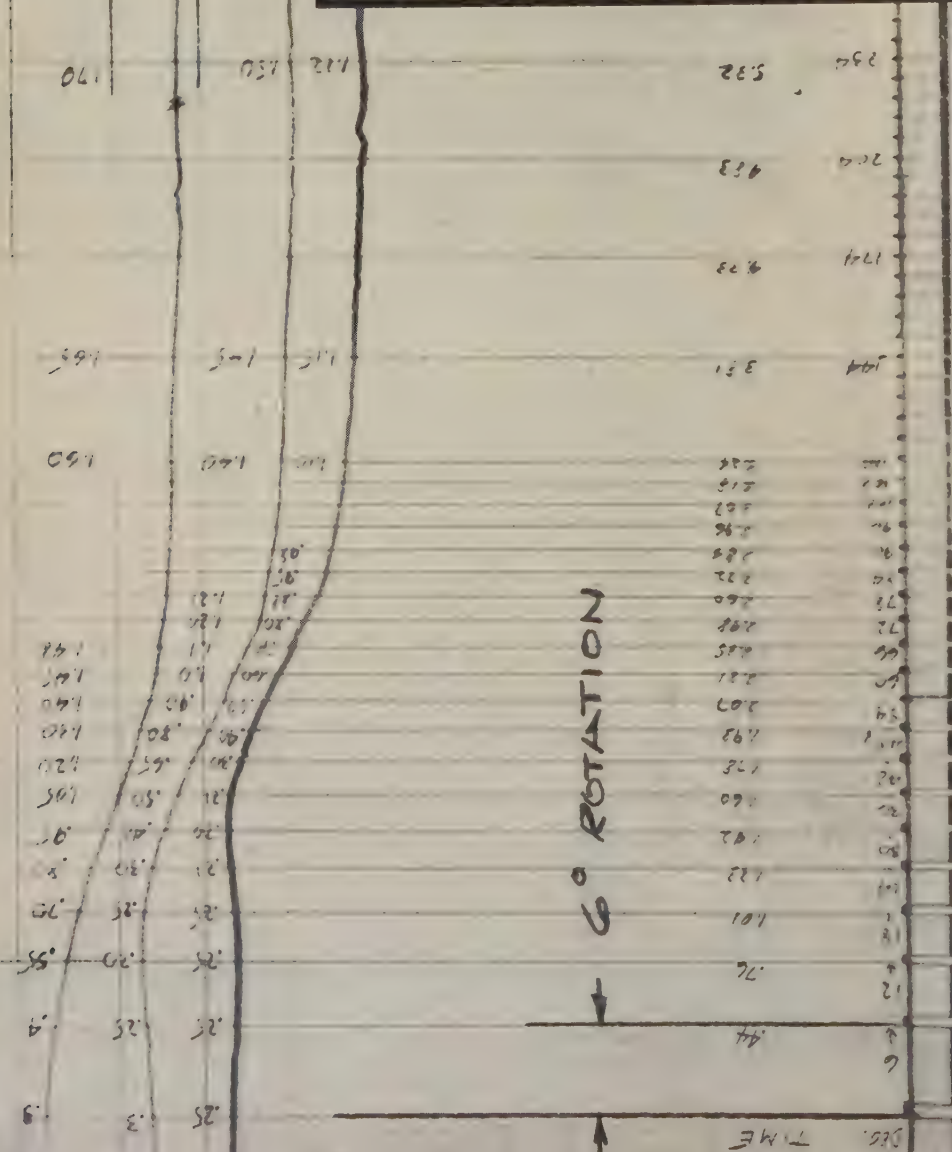
OIL FILM THICKNESS DURING
START

OIL
TEMP 27°C

6° ROTATION MARKS

60N TIMING WAVE

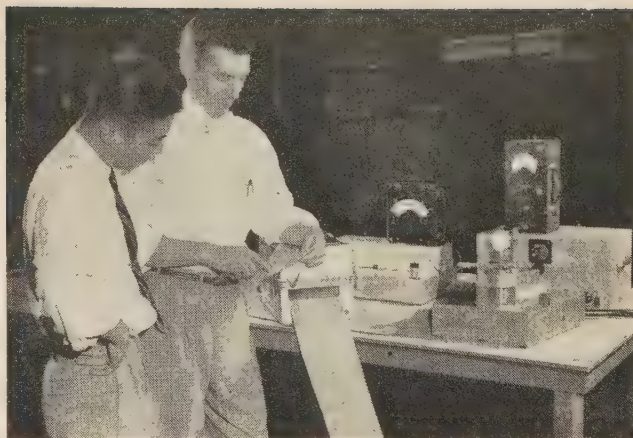
The Visicorder records



Unretouched Honeywell Visicorder record. actual size.

The Westinghouse Electric Corp. used a Honeywell Model 906 Visicorder to make this directly-recorded chart of oil film thicknesses on the bearing pads of a 67,500 KW water-wheel generator supplied for Chief Joseph Dam at Bridgeport, Washington. In these tests, design engineers at Westinghouse wanted to ascertain bearing lubrication factors (oil film thicknesses) as a function of rotation and speed.

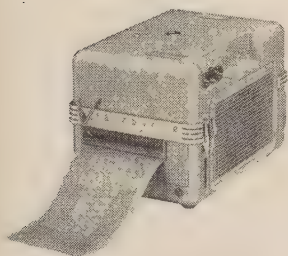
Bearings are designed so that as the water wheel generator comes up to speed, oil is carried mechanically over the bearings, and develops a film thickness that varies from .002 to .005 inches. Film thicknesses at the leading edge, center and trailing edge of one bearing pad were relayed by magnetic reluctance thickness gauges to the Visicorder. The thickness of the film at each of these locations as the bearing passed through each six degrees of rotation are represented by traces #6, 5, and 4 on the chart. Thicknesses as revealed by the test were proved to be close to the predicted design values.



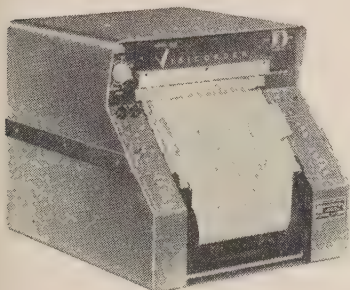
Stephen Chai and Glenn Cooper, Westinghouse development engineers, calibrate the Visicorder and other equipment used in water wheel generator tests.

The Visicorder was selected for these tests because, 1) high galvanometer sensitivities made the use of amplifiers unnecessary, 2) immediate readout was highly desirable and, 3) the portability and ruggedness of the instrument were helpful.

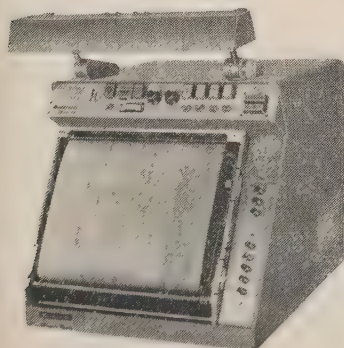
oil-film thicknesses



Recent Models of the 906 Visicorder incorporate time lines and grid lines and record up to 14 simultaneous channels of data.



The NEW Model 1108 Visicorder, with many automatic features and the convenience of pushbutton controls, is ideal for intermediate uses requiring up to 24 channels of data.



The Model 1012 Visicorder is the most versatile and convenient oscillograph ever devised for recording as many as 36 channels of data.

The Honeywell Visicorder is the pioneer, completely proven, and unquestioned leader in the field of high-frequency, high-sensitivity, direct-recording ultra-violet oscillography. Here are some of the reasons why Visicorders provide the most accurate analog recordings available: constant flat response and sensitivity of galvanometers; grid-lines simultaneously recorded with traces to guarantee exact reference regardless of possible paper shift or shrinkage; flash-tube timing system for greater accuracy of time lines; superior optics for maximum linearity of traces.

No matter what field you are in . . . research, development, computing, rocketry, product design, control, nucleonics . . . the high-frequency (DC to 5000 cps) Visicorder oscillograph will save you time and money in data acquisition.

Call your nearest Minneapolis-Honeywell Industrial Sales Office for a demonstration.

Reference Data: Write for Bulletins 1108, 1012, and HC906B

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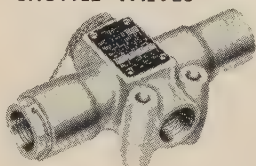
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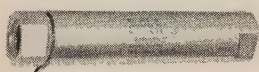
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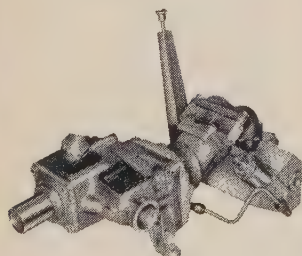
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electronics scanner

ECM POD for fighter interceptors was developed for WADD by North American in a hush-hush feasibility program. The contract, which started in '56, was completed last year when NAA delivered prototypes. Now flight tests have been completed and NAA is hoping for a production order. The pod can be used on some 17 aircraft and also on several drones.

ONE of the hottest areas in electronic warfare is passive direction finding. Passive DFs are designed to locate the source of aircraft-radiated jamming signals. Some of the proposed systems are Parade (by Sylvania), Jamtrack (by MIT's Lincoln Labs), a hyperbolic design (by G. C. Dewey & Co.), Space-track (by General Bronze), and an unnamed design by Motorola.

RUSSIANS are known to have an ECM device that can jam radar and cut out just as soon as the radar goes off the air—so that it will run the smallest possible risk of giving away its position to ground DFs.

EUROPEAN scuttlebut is that the Reds have enough fighters equipped with jammers to blanket our radar defenses.

ON ECM, Western European designers seem largely to concentrate on defense. They are more concerned about what the other side will do to their radar than about what they can do to the other side. In line with this attitude, several European military groups have bought radar simulators equipped with window- and noise-type jamming simulation from Solartron in England.

THOUGH often turned down as not feasible, lethal electromagnetic rays are being studied by electronic-warfare groups at at least a few companies. The Advanced Research Center of GE's Light Military Electronics Dept., for example, is giving the death rays serious consideration.

The advantage of lethal radiated electromagnetic waves is that they would travel at the speed of light. So far, the atmosphere has been

the main barrier, because of attenuation. This problem would not exist in space, so the death-ray searchers might be thinking in terms of a space weapon.

"TOP jammer producer" is how GE&S Light Military Electronics Dept. describes itself. It says it has built "well over 5000 jammers," including designs for every USAF aircraft except Convair's B-58.

HANDBOOK of electronic warfare is being prepared by ARDC for engineers and military technicians. The contributors to the book are top U. S. electronic-warfare experts. Among the editors are Dr. Joseph Boyd, from University of Michigan, and Dr. H. W. Welch, from Motorola.

AN ECM techniques handbook is in preparation by New York University under an RADC contract.

LOOK-THROUGH schemes were developed, in independent programs, by both WADD and the Navy's Research Labs and BuWeps. The two schemes are largely similar.

NEW antenna firm, Aero-Geo-Astram, was founded by design engineers who left Melpar. It is located in the Baltimore-Washington area and has a subcontract from Airborne Instruments Lab for airborne antennas for AIL's \$39 million USD-7 electronic recon program.

TEMCO is installing USD-7 equipment in a KC-135 test bed for extensive flight evaluation. The equipment is built in console-and-rack forms and takes up most of the center section of the KC-135's fuselage.

INERTIAL guidance parts to be used on the Boeing Minuteman ICBM passed rugged tests on the 35,000-ft-long sled track at Holloman AFB, N. M., according to Autonetics, which developed the guidance system. Gyros and velocity meters were tested.

The development program for its Minuteman system is right on schedule, claims Autonetics.

Some Properties of "K" Monel alloy at Low Temperatures

Condition	Temp. °F.	Yield Strength 0.2% Offset psi.	Tensile Strength psi.	Elong- ation % in 2 in.	Reduction in Area %
Cold-drawn, age-hardened	Room*	120,000	160,000	20.0	35.0
Cold-drawn, age-hardened	-110	134,600	171,550	17.3	41.1
Cold-drawn, age-hardened	-300	160,200	202,000	27.0	47.3

*Nominal values

Gets tougher and stronger as temperatures go down

**"K" Monel alloy also resists
oxidation and corrosive attack**

In "K" Monel* age-hardenable nickel-copper alloy, the missile designer has a highly useful material for combined strength, ductility and corrosion resistance at extreme low temperatures . . .

This heat treatable alloy starts with high strength and ductility and improves as temperatures drop to -300°F. Consequently "K" Monel components, whether made by forging, welding, or from common mill forms like tubing, perform as well or better at -300°F than at room temperature.

You can add other outstanding properties to the list, too. For instance, "K" Monel alloy has excellent resistance to oxidizers and many types of corrosives.

This same alloy, unlike many non-ferrous materials, also has high heat resistance . . . good strength and ductility and excellent corrosion resistance well into the 1000°-1200°F range.

Other excellent low . . . and high . . . temperature alloys

Other Huntington Alloy Products, such as Monel* nickel-copper and Inconel* nickel-chromium alloys for example . . . provide excellent combinations of strength, ductility and toughness at low temperature.

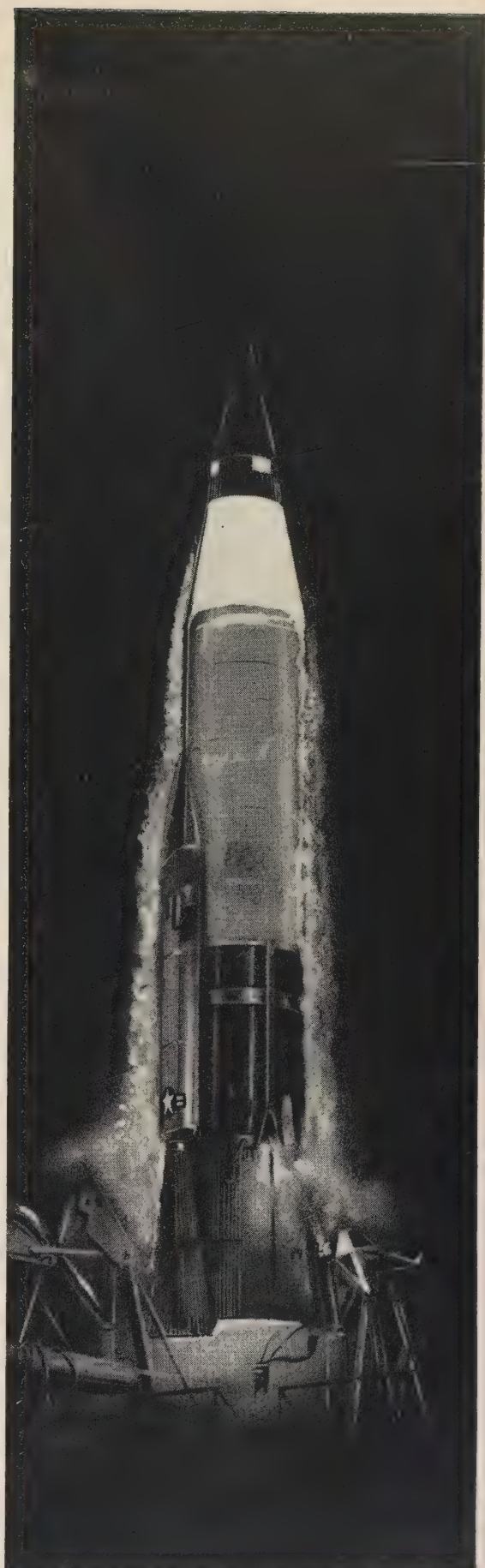
Huntington Alloy Products Division also provides a number of new alloys specially developed for extremely high temperatures . . . Inconel "713C",* a nickel-chromium cast alloy, Inconel "702",* an aluminum-containing nickel-chromium alloy, and Inconel "700",* an age-hardenable nickel-cobalt-chromium alloy. And it's worth noting that these alloys are high performance materials at low temperatures.

For information on low-temperature properties of these standard production alloys, send for "Some Properties of Huntington Alloys at Low Temperatures." Ask about the new high-temperature alloys, too . . . if that's where your special interest lies.

*Inco trademark

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The International Nickel Company, Inc.
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Closeup of ring rolling, showing edging roll and portion of ring.

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letters

Confusing abbreviations

I read with great interest C. De Angelis' . . . "Basic Units of the Metric System," which appeared in your January 1960 issue in the Readers' Round Table department [page 316].

It is very gratifying to see that so many scientists and engineers favor the metric system. However, when one reads De Angelis . . ., one is slightly confused by the multitude of combinations of the various metric units. The reason, perhaps, for this impression is . . . that the author . . . did not point out clearly that the so-called metric system is actually a combination of two systems supplemental to each other: the decimal system of magnitudes and the metric system of units.

The "decimal system of magnitudes" refers to the decimal multiples and fractions of a unit. This unit can be . . . the meter or the second as well as the inch or pound. The "metric system of units" is based on the meter, the unit of length, and its interrelation with the units of area, volume, capacity, weight etc. Since the metric system uses the decimal system of magnitudes and we use in our arithmetic the decimal system of numbers, its simplicity in calculations constitutes a great advantage over the British system, which employs generally the duodecimal system of calculation.

It is very unfortunate that even today, almost 150 years after the introduction of the decimal and metric systems into the scientific and engineering world, . . . very few authors insist on the stipulations of the International Bureau of Weights and Measures. There is utter confusion in abbreviations of decimal fractions multiples as well as of metric units.

The decimal system deals with the designation of quantities and their multiples and fractions. All multiples in the decimal system are expressed by *capital-letter* prefixes, while all fractions are indicated by small-letter prefixes. The prefixes of multiples of 10^6 , 10^9 , 10^{12} , and of fractions of 10^{-6} , 10^{-9} , 10^{-12} are Greek letters, while all the other prefixes use Latin letters. [The prefixes, their names, and the magnitudes of the multipliers they indicate are:]

T (tera), 10^{12} ; G (giga), 10^9 ; M (mega), 10^6 ; K (kilo), 10^3 ; H (hecto), 10^2 ; D (deca), 10^1 ; d (deci), 10^{-1} ; c (centi), 10^{-2} ; m (milli), 10^{-3} ; μ (micro), 10^{-6} ; n (nano), 10^{-9} ; p (pico), 10^{-12}

Prefixes for nano . . . and pico . . . should be Greek lower-case letters. However, because of the fre-

more on page 209

Check Employment Inquiry Form Page 213 ➔

SPACE/AERONAUTICS

SCIENTISTS ENGINEERS



San Diego Civic Center, an original painting by Sammy Pasto, Convair/San Diego artist

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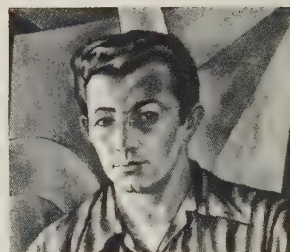
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Department Brochure, simply complete the form below. This entire page may be removed
from the magazine, folded, sealed and mailed in complete confidence.



THE ARTIST — Sammy Pasto, Convair-San Diego artist whose painting appears on the preceding page, is a native of Boston. He studied at the New England School of Art and moved to California following World War II. Presently working as an illustrator at Convair-San Diego, Pasto has received broad recognition for his work in fine arts. He has had one-man shows in New York, Philadelphia and Los Angeles and his work has been accepted in most juried West Coast art shows. For a change of pace, Pasto plays clarinet in a prominent Dixieland jazz band in San Diego.

PROFESSIONAL EMPLOYMENT INQUIRY — This information will enable the professional staff at Convair/San Diego to make a preliminary evaluation of your background. A personal interview can be arranged in your city by appointment. Every completed inquiry will be acknowledged.

PERSONAL INFORMATION (Please Print.)

Name _____ Citizen of what country? _____

Street Address _____

City and State _____ Telephone _____

EDUCATION: College Graduate: Yes ☐ No ☐ Degree: BS ☐ MS ☐ PhD ☐

MAJOR SUBJECT: Physics ☐ Mathematics ☐ Electronic Engineering ☐

Electrical Engineering ☐ Aeronautical Engineering ☐ Mechanical Engineering ☐

Other _____

EXPERIENCE: Primary Specialty _____

Secondary Specialty _____

YEARS OF EXPERIENCE IN PRIMARY SPECIALTY: _____

Additional Comments, if any, concerning your job interests _____

quent use of these letters [to designate] frequency [ν] and . . . the number 2.14159 [τ], Latin . . . letters [n and p] are used instead.

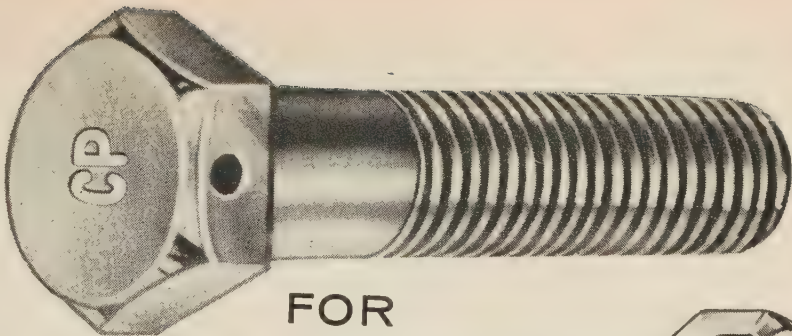
The basic units of the metric system are the meter (m), the unit of length; the gram (g), the unit of mass; and the second (s), the unit of time. It should be pointed out that these fundamental units are abbreviated [as] single Latin [lower]-case letters without a period.

If one wishes to express certain multiples or fractions of the basic unit, of the metric system, one could, for example, write 1000 gram [s as] "1 Kg" (kilogram), and one-millionth of a second [as] "1 μ s" (microsecond).

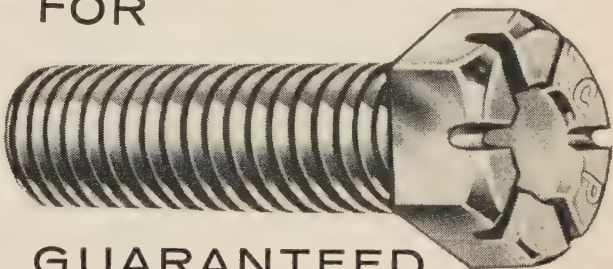
The relationship between the fundamental units and their derived units is very simple. The unit of metric area is one square meter (m^2), and the unit of volume is the cubic meter (m^3). . . . Z. V. Harvalik
Director, Basic Research Group
Engineer Research & Development
Laboratories, U.S. Army
Ft. Belvoir, Va.

● For readers who like to check up on things, we might as well admit right away that SPACE/AERONAUTICS in its metrical abbreviations does not in every instance follow the rules laid down by the International Bureau of Weights and Measures, which are explained so clearly by Mr. Harvalik. The exceptions are:

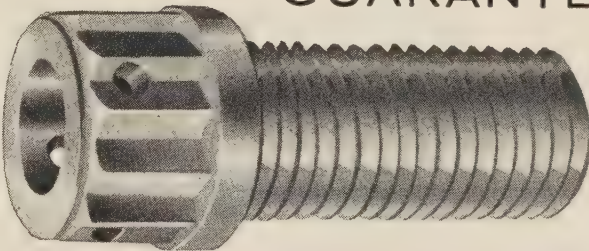
- (1) Instead of the lower-case Greek mu, we use "u" to designate "micro" as a matter of typing and printing convenience. (An exception to the exception is the abbreviation for micron, which is m —a "u" by itself would look rather silly.)
- (2) Our abbreviation for gram is "gm" instead of "g" to avoid confusion with the abbreviation for acceleration due to gravity.
- (3) Second is abbreviated "sec" rather than "s" on the grounds that single letter abbreviations are apt to be overlooked and therefore should be kept to a minimum.
- (4) "Kilo" is indicated by a lower-case letter instead of a capital ("k" rather than "K") for reasons of somewhat doubtful cogency—"kg" is widely written even by Continental users of the metric system, and there tend to be too many capital letters in modern written English as it is.—ED.



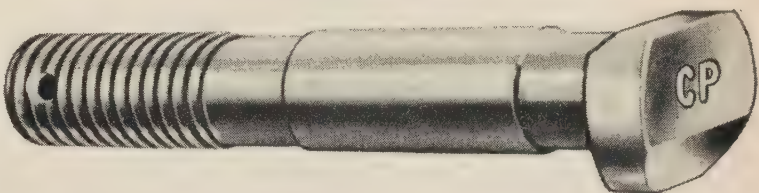
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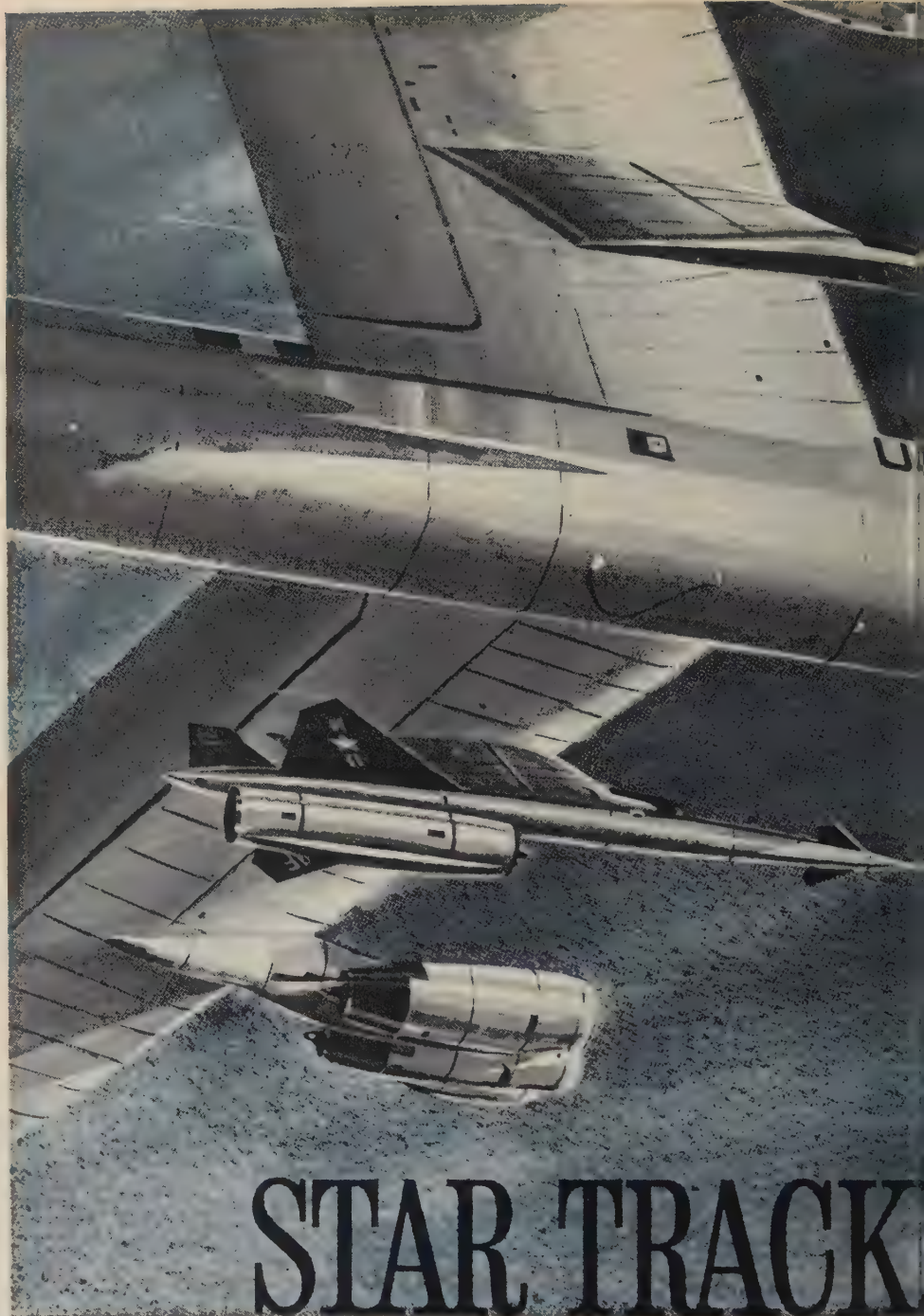
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Ground Support Equipment Engineering



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engineers, scientists...check these careers with Honeywell Ordnance

in Minneapolis

Honeywell Ordnance in Hopkins (suburb of Minneapolis) designs and produces missile systems and components. Primary areas of interest include missile warhead systems and components, fuzing, stabilization systems, underwater ordnance, and communications equipment. At present, openings exist for the following:

INFRARED, DEVELOPMENT ENGINEER—Graduate engineer with 3 to 5 years' experience in electronics; 1 to 3 years' in infrared systems, design, and applied research. Knowledge of optic system applications desirable.

AWS, SYSTEMS ANALYST—B.S. or preferably M.S. in physics, math, M.E., or E.E. Physics and math background with systems experience in ASW or underwater ordnance. Lab experience in ASW is desirable.

RF-VHF, DEVELOPMENT ENGINEER—Graduate engineer with 3 to 5 years' RF development experience. Design experience in RF circuits in VHF range and up. Radar-type pulse circuits and antenna design experience desirable.

PROCESS ENGINEER—BSEE or equivalent with up to 4 years' experience. Collaborate with design to insure that specifications, standards, and physical characteristics of product are consistent with capabilities of production and assembly process to produce high acceptance rate.

If you are a qualified engineer interested in one of these opportunities with Honeywell Ordnance in Minneapolis, write in confidence to Mr. R. C. Duncan, Dept. 545A, Honeywell Ordnance, 2753 Fourth Avenue South, Minneapolis 8, Minnesota.

in Duarte, California

Honeywell Ordnance in Duarte (near Pasadena) is a design and prototype production center for Anti Submarine Warfare: overall system analysis, design and development of missile systems, components, support equipment, and trainers. At present, openings exist for the following:

SENIOR COMPUTER ENGINEER—Graduate in Electrical Engineering or physics with experience in the development of digital circuits, switching matrices and conversion problems.

QUALITY CONTROL AND RELIABILITY ENGINEER—Graduate in Electrical Engineering with experience in the electronic industry on quality control and/or reliability problems.

GENERAL ELECTRONICS ENGINEER—Graduate in Electrical Engineering; good general electronics experience with emphasis on circuitry development.

OPTICS ENGINEER—Graduate in Mechanical Engineering or Physics with several years' experience in optical systems design. Electrical background required.

* * *

If you are a qualified engineer interested in one of these openings, send information on your background and accomplishments to Mr. James Christensen, Dept. 545A, Honeywell, 1724 South Mountain, Duarte, California.

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To explore professional opportunities in other Honeywell operations coast to coast, send your application in confidence to H. D. Eckstrom, Honeywell, Minneapolis 8, Minnesota.

April 1960
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We will do the rest and promptly forward a copy of your Inquiry Form to each of the organizations you have checked. Depending on their specific personnel requirements, they will get in touch with you at your home.

I am interested in the employment opportunities at:

<input type="checkbox"/> AC—The Electronics Div. of GMC	103	<input type="checkbox"/> Raytheon Mfg. Co.	219
<input type="checkbox"/> Avco Corporation; Crosley Div.	220	<input type="checkbox"/> Republic Aviation Corp.	220
<input type="checkbox"/> Convair; Astronautics Engrg. Div.	207, 208	<input type="checkbox"/> Rocketdyne; A Div. of North American Aviation, Inc.	218
<input type="checkbox"/> General Motors Corp.; AC—The Electronics Div.	103	<input type="checkbox"/> Rohr Aircraft Corp.	216
<input type="checkbox"/> Grumman Aircraft Engrg. Corp.	217	<input type="checkbox"/> Ryan Aeronautical	110
<input type="checkbox"/> Jack & Heintz, Inc.	216	<input type="checkbox"/> Space Technology Labs.	27
<input type="checkbox"/> Lockheed Aircraft Corp.; Calif. Div.	331	<input type="checkbox"/> Texas Instruments	215
<input type="checkbox"/> Martin Co., The; Denver Div.	Second Cover	<input type="checkbox"/> Westinghouse Electric Corp.; Baltimore Div.	221
<input type="checkbox"/> Minn.-Honeywell Reg. Co.; Ordnance Div.	212, 220		
<input type="checkbox"/> RCA; Air Systems Div.	218		

OTHER (Some organizations' recruitment advertising in this issue may have arrived too late for inclusion in the above list. If you are interested in the employment offers of any of these organizations, just note its name and the page number of its advertisement in this space. Please refer only to ads keyed to this form.): _____

NOTE: If you have an immediate interest in any special employment opportunity advertised in this issue and would like to give more details about your qualifications than can be noted on this Form, we advise you to send your resume directly to the person or department given in the advertisement. We'd appreciate it if you'd mention SPACE/AERONAUTICS in your application.

April 1960
(good until 6/15/60)

Employment Inquiry Form

Please type or print (with pencil)

(NOT an application for employment)

FIELDS OF INTEREST (in order of importance, note the general fields in which you would like to work—e.g., basic research, dynamics, structures, rocket propulsion, electronic systems, pneumatics, testing, materials, production, ground support, etc.): _____

SPECIALIZED JOB EXPERIENCE (describe the specific technical areas in which you have worked—e.g., flutter, fatigue, fuel systems, circuit miniaturization, servo systems, hydraulic pumps, tool engineering, orbit mechanics, telemetry, data processing, wind tunnel testing, etc.): _____

JOBS AND EDUCATION

List your last 3 employers:

EMPLOYER	CITY & STATE	YEARS EMPLOYED	JOB TITLE OR FUNCTION

List your college and university degrees:

SCHOOL	YEARS ATTENDED	DEGREE

Special Training _____

PERSONAL DATA

AGE U. S. CITIZEN ☐ YES ☐ NO If not, when do you expect to become a citizen?

Name:

Home Address:

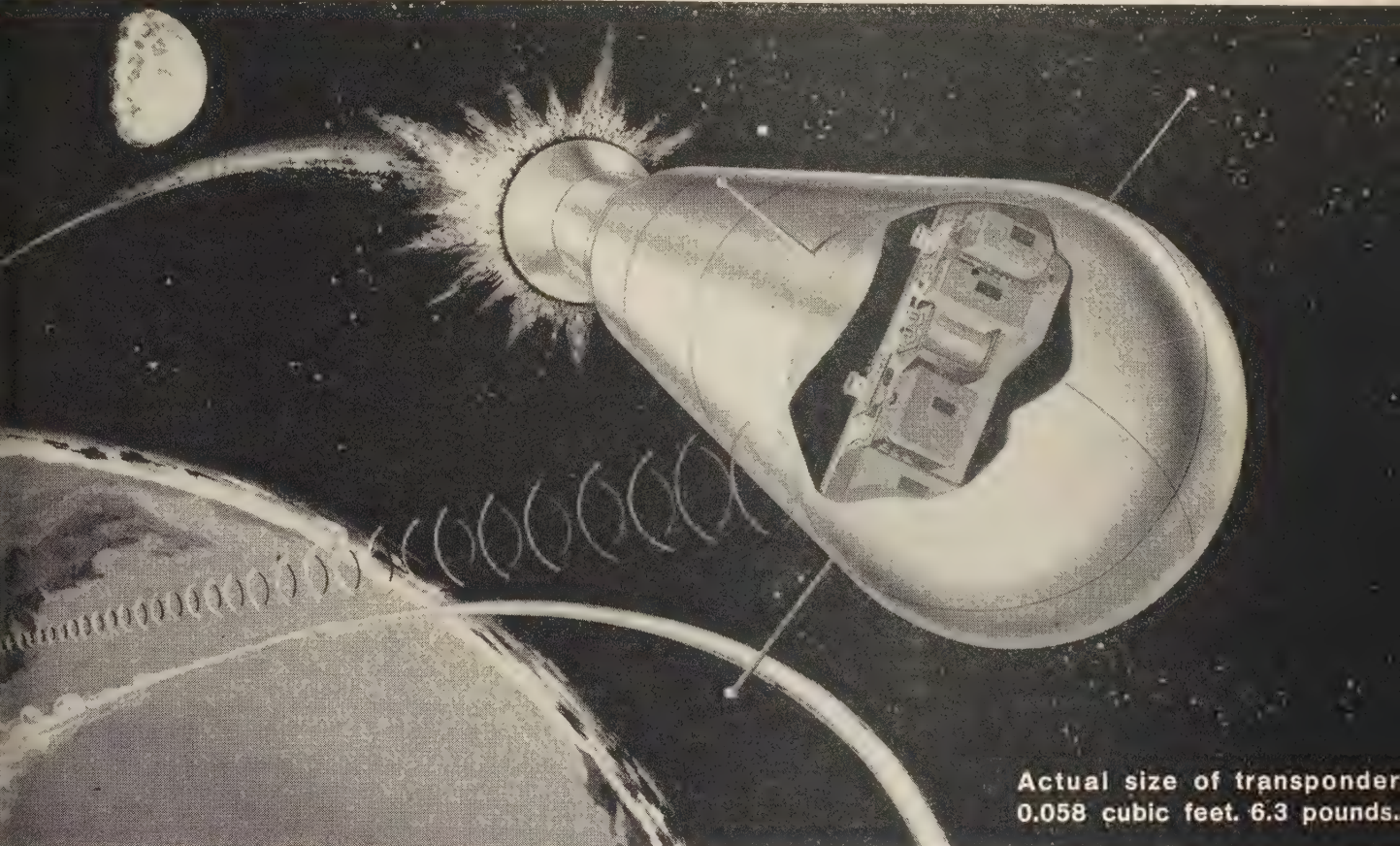
Home Telephone:

Make sure you have checked the companies you are interested in on the other side of this Form. Then put the Form in a stamped envelope and mail it to Space/Aeronautics.

IDEA

Problem: SATELLITE TRACKING BEYOND SKIN RANGE. Create a solid-state uhf transponder that can be included in the payload of a space probe without usurping valuable instrumentation space. TI Apparatus division engineers gained the highest component densities ever achieved in a transponder by designing entirely new circuits with TI mesa uhf transistors, recently developed by the TI Semiconductor-Components division, and packaging them in individually shielded modules.

Result: In a missile shot just 2½ months after the start of this program, the transponder made possible tracking beyond the skin range with absolute reliability, and helped tracking site personnel predict final trajectory early in flight without the usual wait for down-range reports.



Actual size of transponder
0.058 cubic feet. 6.3 pounds.

design, manufacturing and quality control engineers — 3-10 years experience

ORIGINAL IDEAS BECOME REALITIES AT TI

The development of this new transponder is only one example of how TI's engineering activities are combined in an atmosphere of intellectual freedom, to transform original ideas into product realities.

At TI's Apparatus division, it's easier to put your ideas into space... you have the opportunity to work on TI's Central Research Laboratory for basic research, the Semiconductor-Components division for the latest component advances, the GeoSciences and Instrumentation division for world-wide facilities and new knowledge in geophysics, and Apparatus division's own R & D department for product application development.

Engineers with the qualifications specified here are invited to write to John R. Pinkston, Professional Placement, Dept. 121, Apparatus division. To learn more about TI, write for a copy of "We Can Tell You This Much About Apparatus Division."

selected current career opportunities

SENIOR ELECTRONICS ENGINEER: Apply signal detection theory to advanced radar receiver design. (5 years' experience with advanced EE or Physics degree preferred.)

SENIOR DESIGN ENGINEER: Advanced missile system digital computer design with solid-state circuits, logic and memory. (5 years' experience with MS in EE or Physics.)

DESIGN ENGINEER: Microwave R & D with parametric amplifiers, tunnel diode devices, and other advanced components. (3 years' experience with BS in EE or Physics.)

MANUFACTURING ENGINEERS: Complete manufacturing planning and coordination of electronic and electro-mechanical equipment. (3 years' experience with BS in EE, ME, or IE.)

METHODS ENGINEERS: Producibility design, tooling, estimating, and production methods for electronic and electro-mechanical equipment. (4 years' experience with BS in ME.)

QUALITY CONTROL ENGINEER: Establish and maintain quality standards and inspection methods. (3 years' experience with BS in IE, ME, or EE.)

PROFESSIONAL
PLACEMENT

APPARATUS
DIVISION

TEXAS  INSTRUMENTS
INCORPORATED
6000 LEMMON AVENUE • DALLAS 9, TEXAS

*PROGRESSIVE MANAGEMENT



***Another reason
ROHR is a company known by the
PEOPLE it keeps!**

Progressive, "shirt-sleeve" management has guided Rohr to a pace-setting position in the aerospace industry—a position that means greater rewards to people who join the company.

Rohr's carefully charted course of diversification and growth has resulted in unusual stability and a record backlog of nearly a quarter billion dollars, well over half in commercial contracts.

Sound management is not a happenstance at Rohr. The company long ago embarked on a series of programs to develop and encourage management skills among its people. Newest technique is mobile training units, illustrated below... a method pioneered by Rohr.

Progressive management, product diversification, expanding facilities, distinguished associates, fine living conditions... these are among the many reasons that Rohr is *the company known by the people it keeps!*

Rohr invites inquiries from men who can contribute to the company's leadership in the aerospace industry. Write to Mr. J. L. Hobel, Industrial Relations Manager, Rohr Aircraft Corporation, P.O. Box 878-L, Chula Vista, California.



WORLD'S LARGEST
PRODUCER OF
COMPONENTS FOR FLIGHT



Chula Vista & Riverside, Calif.

Check Employment Inquiry Form on Page 213



If **POWER** appeals to you

... You'll like it here ... because power is our business. POWER CONVERSION, CONTROL, FREQUENCY CHANGING, REGULATION, ADVANCED ELECTRICAL SYSTEMS

We need:

Solid-State Electronics

EE with experience in electronic circuit design for advanced work on conversion and control equipment using solid-state devices and magnetic amplifiers.

Electric Power Systems—Research

PhD electrical for power systems analysis and power conversion development.

MSEE with experience feedback controls, analog computation and systems simulation.

ME experience high-speed, high-temperature electrical machinery design for space power plant research.

Heat Transfer & Vibration

ME or MS in math—for analytical work in thermodynamics and heat transfer.

ME with knowledge of instrumentation for shock and vibration test.

Exciting future in new product development with Jack & Heintz, an aggressive leader in the aero-space field.

Wonderful working conditions. Jack & Heintz is big enough to have the most modern facilities and lab equipment, yet small enough to avoid bureaucracy.

Relaxed suburban living. We're located in a beautiful Cleveland residential area. University facilities are close at hand, if you'd like to take advantage of our company-supported educational program.

Send detailed confidential resume to:

Mr. C. E. FORBES,
Manager of Technical Employment

JACK & HEINTZ, Inc.

SYSTEMS FOR GROUND SUPPORT,
MISSILES, AIRCRAFT

17600 Broadway Avenue • Cleveland 1, Ohio

* For an example of J&H development work, see our advertisement in this issue.

Check Employment Inquiry Form on Page 213
SPACE/AERONAUTICS

EXPANSION

to keep pace with the growing

CHALLENGE of ELECTRONICS

at Grumman Aircraft

Grumman Aircraft Engineering Corporation's long and continuing responsibilities for the design of Avionics Systems for ASW, AEW, Reconnaissance, and all-weather attack aircraft has necessitated vast facilities expansion. A new, five million dollar Avionics Systems Center will provide 62,000 square feet of floor space devoted exclusively to activities involving test, evaluation and integration of Avionics Systems.

Concurrent expansion of our staff of electronics engineers and scientists has created positions for men anxious to participate in varied and intellectually stimulating programs utilizing the most modern of facilities.

★ Radar Systems Engineer

EE or Physics degree with a minimum of 5 years' experience in the design, development or analysis of advanced radar systems. Work will consist of Analysis; Preparation of Specifications; Vendor Liaison; Test and Evaluation; Flight Development of the latest airborne radar equipment and systems. Responsibilities include the development of support equipment for these systems.

★ Digital Computer Systems Engineers

BSEE with a minimum of 5 years' experience in the design, development and analysis of digital computers. Should be thoroughly familiar with logical design, circuit techniques, encoders, decoders, magnetic storage devices and programming. Must be capable of integrating the computer system with the entire Avionics System.

★ Automatic Flight Control Systems Engineers

EE or Physics degree with a minimum of 5 years' experience in the design and development of autopilot and flight simulators. Work will involve the development of airborne flight control systems and the establishment of military automatic test equipment requirements.

★ Communications Equipment Engineer

Electronics Engineer with a minimum of 5 years' experience, with thorough knowl-

edge of single sideband theory and its application. Should possess a complete understanding of AM, FM, PM and single sideband modulation processes and their application as well as techniques. Must have experience in analyzing and testing communication receivers and transmitters, and should be thoroughly familiar with HF and UHF antennas and associated propagation problems. A background in digital equipment; encoder, decoder and magnetic storage devices is an important consideration.

★ Laboratory Equipment Engineers

BSEE with 7-10 years' experience in laboratory test programs of airborne Avionics equipment. A working knowledge is required in a majority of the fields of airborne communication, detection, electrical systems, automatic flight control and navigation. An understanding of commercial power systems, electrical distribution, building design and electronic test instrumentation of all types is also necessary.

★ Avionics Support Equipment Engineers

Electronic Specialists in system analysis of airborne digital computers, advanced radar systems, and navigation and communication systems. These Specialists will establish test point requirements and test logic for military automatic line test devices and automatic and manual military shop test equipment. Physics or EE degree required, plus a minimum of 3 years' experience in

Avionics support or airborne equipment design and development.

★ Radio Interference Control Engineers

Engineers to analyze the source of conducted and radiated noise interference caused by the interaction of complex electronic equipments and systems; and develop methods and techniques to suppress the interference in the advanced design state of aircraft and missiles.

★ Radome or Antenna Design Engineer

BSEE or Physics degree with a minimum of 3 years' experience in radome design. Background in classical Electromagnetic theory and advanced math essential. Work consists of analysis and synthesis of radomes or antennas on current and advanced designs, including the use of the IBM computer facilities to develop design techniques.

★ Technical Liaison Engineers

Minimum 8 years' combined technical education and experience. Work with and instruct technicians in the test and adjustment of advanced electronic equipment both in a laboratory and after installation in aircraft. Area of work experience should include one or more of the following: Aircraft Instruments, Aircraft Power Systems, Automatic Flight Control Systems, ASW Equipment, Analog and Digital Computers, Data Communication, Data Display, Data Processing, Electronic Countermeasures, Inertial Guidance, Magnetic Detection, Navigation, Radar.

You are invited to investigate these opportunities by sending your resume to Mr. T. Wilder, Manager, Engineering Employment, Dept. GR-80, who will arrange an interview at your convenience. (U. S. Citizenship required.)



GRUMMAN

AIRCRAFT ENGINEERING CORPORATION

Bethpage • Long Island • New York

Check Employment Inquiry Form on Page 213

Systems Engineers . . .

Take a

GIANT STEP

with RCA's
**AIRBORNE
SYSTEMS
DIVISION**

This far-reaching activity is involved in engineering development, design, and manufacture of all types of airborne—and undersea—electronic systems and equipment. Current projects necessitate conception of several complete weapon system support units (including missile and outer-space gear), communications, electronic warfare, and undersea warfare systems.

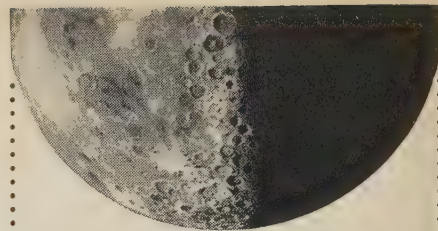
As an RCA systems engineer, you will not only be responsible for creating some of today's most vital strategic defense weaponry . . . but will be able to advance rapidly, *as an individual*, on a highly liberal merit basis. This is an extremely unusual growth situation. To keep you free for only *creative* activities, a vast array of well-staffed, well-equipped facilities—both research and manufacturing—are on hand to support you at all times.

A select number of openings now exist for systems engineers and operations research personnel with broad experience in military systems. If you qualify . . . and are ready to take a giant step forward in your *professional* career . . . please send a résumé to:

Mr. C. B. Gordon, Dept. SA-40
Professional Placement Office
RCA, Bldg. 10-1
Camden 2, New Jersey



RADIO CORPORATION of AMERICA
DEFENSE ELECTRONIC PRODUCTS



ROCKETDYNE

*announces**immediate openings in*

ELECTRICAL PROPULSION

for

PHYSICISTS

Rocketdyne, the nation's leader in Research and Development of high and low thrust propulsion systems, is expanding its Electrical Propulsion Activities in Southern California.

PROJECT LEADER to direct experimental research and development of electrical thrust devices. A PhD in experimental physics and experience with ion sources, ion acceleration and collimation, ion-electron recombination and charged particle detection, desirable.

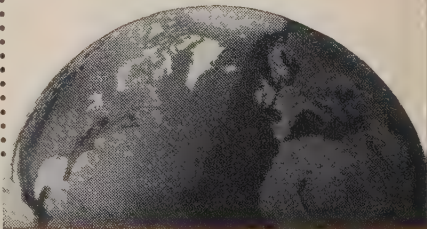
SENIOR PHYSICIST plan and conduct experimental research on such electrical propulsion devices as ion and plasma jet engines. Work includes development and testing of ion sources, accelerating-electrode arrangements, beam neutralization devices, and measurement of such parameters as the current, power and thrust of the ion beam. PhD or MS in experimental physics, and experience with high vacuums, and with the acceleration and detection of charged particles, desirable.

SENIOR PHYSICIST. Plan and conduct theoretical research, such as the design of accelerating and collimating electrode systems, and analysis of space missions, using large digital computers. PhD or MS in Physics, and advanced study in celestial mechanics and electrostatics, desirable.

Address inquiries to:
Mr. J. C. Peck, Dept. 596-F.D.
6633 Canoga Avenue
Canoga Park, California

ROCKETDYNE

A DIVISION OF NORTH AMERICAN AVIATION, INC.
First with Power for Outer Space



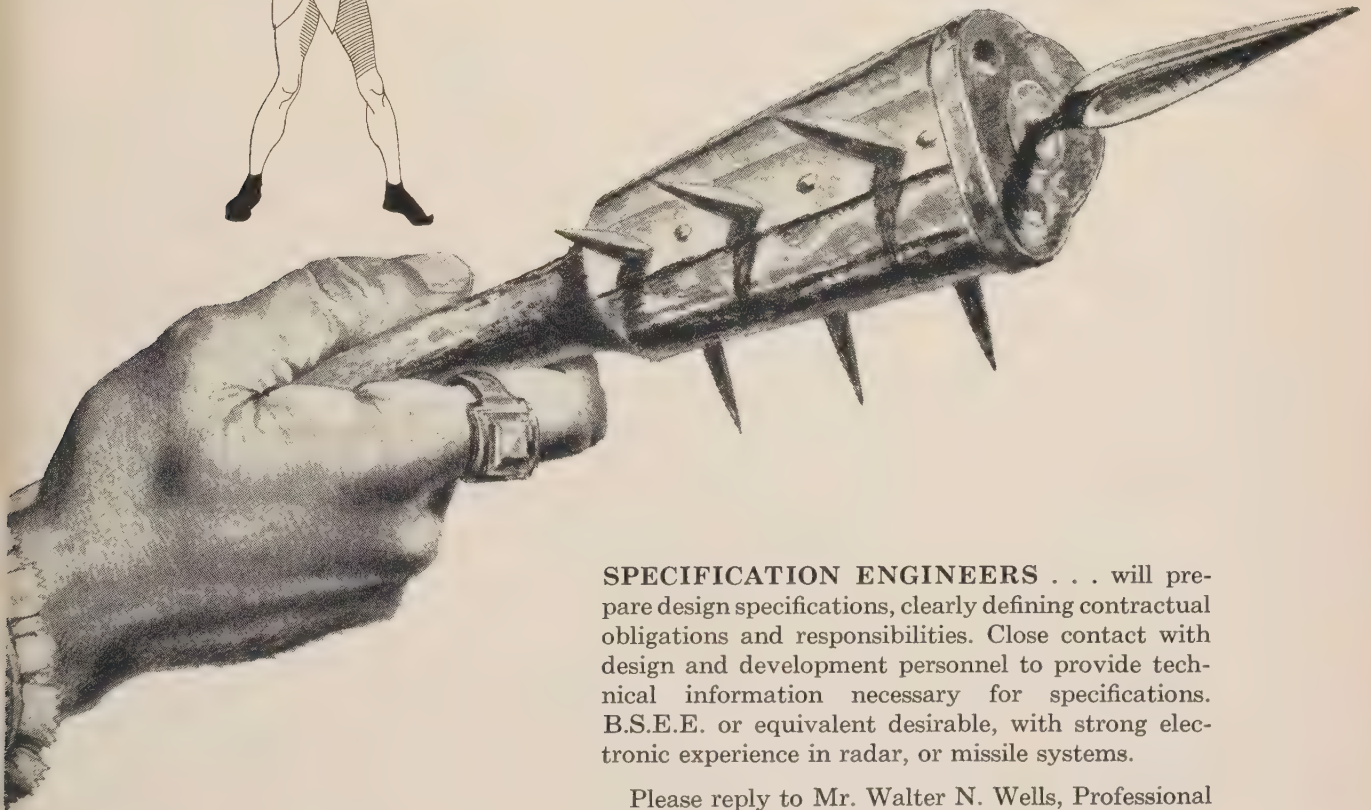
This "bazooka" type cannon of 1395 fired lead, lapidary and finned missiles. Their main disadvantage — practically impossible to aim or guide to its target. The missile was named after Henry VIII because he was considered a connoisseur of walking sticks which were often used to conceal weapons.

Today, as a vital part of one of the world's largest electronics companies, Raytheon's Missile Systems Division is making significant contributions to the art of missilry. The exciting new Pin Cushion Project for selective missile identification, the constantly advancing Navy's air-to-air SPARROW III and Army's HAWK are examples of their outstanding creative work.

We are seeking highly creative people to maintain Raytheon's leadership in this challenging field. For these people, Raytheon's Missile Systems Division creates a climate for talent — perhaps *your* talent.



14th CENTURY: WALKING STICK



SPECIFICATION ENGINEERS . . . will prepare design specifications, clearly defining contractual obligations and responsibilities. Close contact with design and development personnel to provide technical information necessary for specifications. B.S.E.E. or equivalent desirable, with strong electronic experience in radar, or missile systems.

Please reply to Mr. Walter N. Wells, Professional Personnel, Missile Systems Division, Raytheon Company, 520 Winter Street, Waltham, Mass.

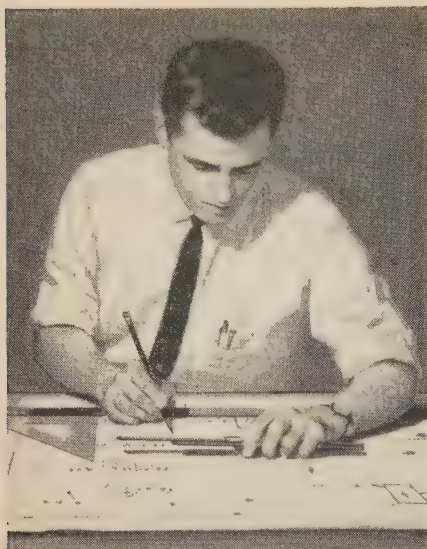
19WSE



**MISSILE
SYSTEMS
DIVISION**

...creates a climate for talent.

Check Employment Inquiry Form on Page 213



digital computer designers

The Crosley Division of Avco Corporation has openings for electronic engineers with from two to ten years' experience for unusually responsible positions involving digital computer and data processing equipment design.

At Crosley, all projects offer engineers of talent and capability unlimited challenge and definite authority. An alert, aggressive management team provides maximum support and backing to each of the outstanding professional teams working on the frontiers of data processing for industrial systems.

Now is your opportunity to grow your own career in this new and exciting field. Experienced personnel can choose:

- transistorized circuit design
- digital systems design
- logic design

For complete information, write or call:

Mr. P. B. Olney
Manager of Scientific and
Administrative Personnel
Department 40
Crosley Division
Avco Corporation
1329 Arlington Street
Cincinnati 25, Ohio
Phone: KIrby 1-6600.

Avco // **Crosley**

Check Employment Inquiry Form Page 213

DESIGN ENGINEERS


*check these openings in
advanced gyro and electrical
components design*

In 1949, Honeywell developed and flight tested the floated gyro for control systems. Since then, its Gyro Design Group has become the focal point for a multi-million dollar component development program, supporting the inertial navigation industry. This is, perhaps, the most advanced program of its kind. It has expanded rapidly and now has openings for additional top level engineers.

This group is involved in all fields of gyro design. It works in such areas as *precision gyro and accelerometer design, hydro-dynamic bearings, vibratory mechanisms, precision electric suspension techniques and gyro magnetics.*

The men needed to fill these positions should be capable of developing advanced concepts for gyros and of following through on their projects. They should have a minimum of two years' (and up to twenty years') experience in such areas as *precision gyro mechanics, servo techniques, digital data handling, electronics packaging, advanced instrumentation, or magnetic component design.*

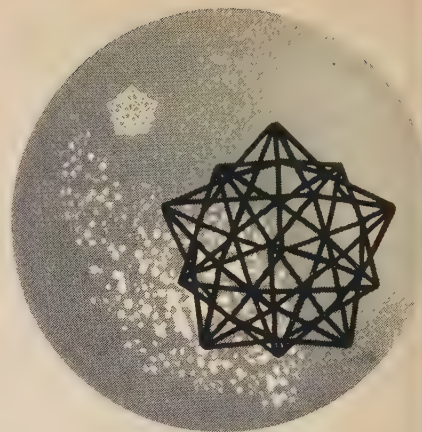
If you are a qualified, interested engineer, we would like to hear from you. Just drop a line including pertinent information on your background, interests, and accomplishments to Mr. Bruce D. Wood, Dept. 545B.

Honeywell 

AERONAUTICAL DIVISION
1433 Stinson Blvd. N.E., Minneapolis 13, Minnesota

To explore professional opportunities in other Honeywell operations coast to coast, send your application in confidence to H. K. Eckstrom, Minneapolis 8, Minnesota.

Check Employment Inquiry Form Page 213



ENGINEERS
SCIENTISTS

FUTURISM in contemporary R&D

Radical departures from traditional forms of scientific investigation are the keynote of Republic Aviation's forward-looking programs in space exploration and upper atmosphere flight. In an environment that regards with skepticism the seeming validity of conventional conclusions, engineers and scientists seek below-the-surface solutions of problems... bypassing the superficial.

Expanding the scope and depth of present programs is Republic's recently completed \$14 million Research and Development Center. Extensive facilities here are an invitation to professional men to realize the future by solving today's most perplexing problems.

SENIOR LEVEL OPENINGS EXIST IN THESE IMPORTANT AREAS:

Space Electronics (*Guidance, Navigation, Communications*) / Hypersonics / Hydromagnetics / Nuclear Power Packages / Advanced Computer Technology / Applied Mathematics / Space Environmental Studies (*Life Science*) / Celestial Mechanics / Electronic Theory / Plasma Physics / Radiation Studies / Re-entry Techniques / Fluid Mechanics / Materials Research & Development

Please forward resumes to:
Mr. George R. Hickman
Technical Employment Manager,
Department 6D

 **REPUBLIC AVIATION**

Farmingdale
Long Island, New York

Check Employment Inquiry Form Page 21
SPACE/AERONAUTICS

LISTEN!...

To the Westinghouse-Baltimore Story



Before you make your career decision, you should hear the story that is now unfolding at the Baltimore Divisions of Westinghouse. Get the facts on the exciting programs now under way . . . including advanced development work on new weapons systems with revolutionary data processing, antenna systems, and system synchronization. If you are beginning or continuing your career as an electrical or mechanical engineer, we would welcome the opportunity to give you the facts about career opportunities in the following fields:

**MICROWAVE SYSTEMS
SYSTEM SYNCHRONIZATION
SYSTEMS RELIABILITY PREDICTION
MOLECULAR ELECTRONICS
ADVANCED DATA DISPLAYS
LIAISON AND FIELD ENGINEERING
MECHANICAL DESIGN & PACKAGING
DIGITAL COMPUTER DESIGN
ADVANCED ANTENNA SYSTEMS
ADVANCED SYSTEMS AUTOMATED TEST
TRANSMITTER AND RECEIVER SYSTEM DEVELOPMENT
TRANSFORMER DESIGN**

Send resume to: Mr. A. M. Johnston, Dept. 278

Westinghouse

BALTIMORE

P. O. Box 746

Baltimore 3, Maryland

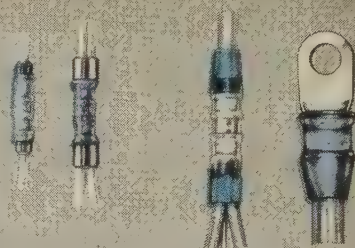
AIR ARM • ELECTRONICS • ORDANCE

Check Employment Inquiry Form on Page 213



STRATO-THERM TERMINALS AND SPLICES

- up to 1200°F. operating temperature
- solid, stranded or combination conductors
- shock and corrosion resistant
- wire size range 22-10 AWG
- serrated inner barrel for maximum tensile strength



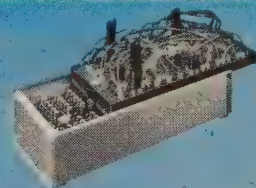
CERTI-SEAL SPLICES AMPLI-NYL TERMINALS AND SPLICES

- combined wire size range 22-2/0 AWG
- exceed millivolt-drop specifications
- finest nylon pre-insulation
- shock and corrosion resistant
- color coded by wire size

BECAUSE CIRCUIT RELIABILITY IS VITAL . . .

. . . AMP's product is more than fine circuit terminals . . . more than remarkably precise compression-crimp tooling . . . more than an error free, fast method of attachment.

AMP's product is finished crimp-type terminations on your circuitry wires . . . by the hundreds or millions . . . of the highest reliability . . . performing under gruelling conditions . . . from basic terminals to complete patchcord systems.

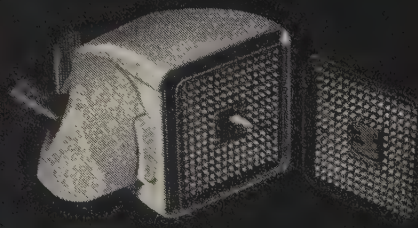


PATCHCORD PROGRAMMING UNITS (Airborne "240" shown)

- universal or shielded systems
- patented wiping action pre-cleans pins and contact springs
- nylon sleeve insulates and firmly seats patchcord pin in board
- contacts have rear board accommodation for taper pins to provide reliable solderless lead terminations

200 CONTACT CABLE CONNECTORS

- extremely reliable disconnect for ground electronic and instrumentation application
- connector can be electrically disengaged without mechanical separation
- five indexed positions to permit strain-free cable exit
- identical inserts and contacts in both halves
- polarized to prevent improper coupling—has numbered cavities to assure proper circuit identification



COMPLETE INFORMATION ON THESE FOUR PRODUCT LINES IS AVAILABLE ON REQUEST.

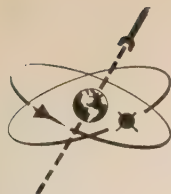
AMP INCORPORATED

GENERAL OFFICES: HARRISBURG, PENNSYLVANIA

A-AMP products and engineering assistance are available through subsidiary companies in: Australia • Canada • England • France • Holland • Japan

Write in No. 334 on Reader Service Card at start of Product Preview Section

SPACE/AERONAUTICS



product index to advertising

THIS IS A SPECIAL REFERENCE to the product information given in the advertisements in this issue. It is intended solely to help the reader make the best use of these ads. Therefore the index does not necessarily cover all the products made by each advertiser. Also, definitions and cross-listings are not intended to exhaustively describe each product but merely to make sure that each product can be found with reasonable ease by the reader looking for it.

Similar indexes to services and employment opportunities featured in ads follow this index.

Advertisements for which complete proofs were not available to the Editorial Department by the closing date are not necessarily covered by these indexes. (Proofs can be forwarded internally by the Production Department only for advertisements meeting the closing dates.)

For more detailed information on any product or service advertised in this issue or featured in its Product and Data Reviews, use the handy Reader Service Card.

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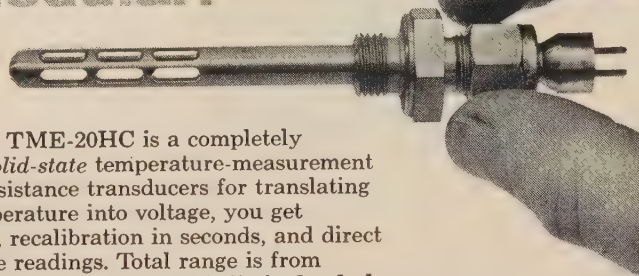
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ARNOUX'S NEW TME-20HC SYSTEM PROVIDES 20 to 200 CHANNELS OF TEMPERATURE INFORMATION

...it's modular!



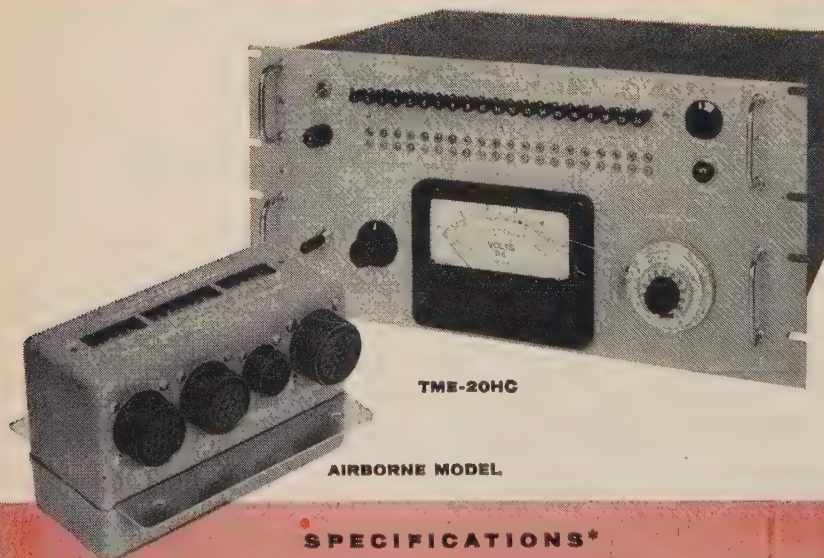
ARNOUX's new TME-20HC is a completely self-contained, *solid-state* temperature-measurement system. Using resistance transducers for translating a change of temperature into voltage, you get adjustable range, recalibration in seconds, and direct high-level-voltage readings. Total range is from -320°F to $+1000^{\circ}\text{F}$. Response time is limited only by the selected resistance temperature transducer. Per-channel cost is low compared to systems using thermocouples because voltage amplifiers are not required.

The TME-20HC unit contains 20 channels, each adjustable from 0 to 5 volts output over a desired temperature range.

Associated TCE-20HC provides a convenient and accurate method of channel calibration. An airborne unit is also available... it's small and lightweight. Bulletin 501.

Arnoux Corporation

11924 W. Washington Blvd., Los Angeles 66, California



SPECIFICATIONS*

TME-20HC BALANCE AND POWER UNIT

1. Number of temperature channels: 20
2. Type of temperature transducers: standard 20,000-ohm resistance
3. Adjustment and monitoring circuits: all necessary circuits incorporated
4. Temperature-measurement range: -325°F to $+1000^{\circ}\text{F}$
5. Temperature-measurement span: each channel adjustable to any desired span
6. Output voltage: 0 to 5 vdc for 275°F minimum temperature span
7. System stability: 0.25% of full scale
8. System ambient temperature range: $+20^{\circ}\text{F}$ to $+120^{\circ}\text{F}$
9. Power requirements: 105 to 125 vac, 60 cps, single phase

10. Size and mounting: 3.5 x 19 inch panel for standard rack mounting

11. Finish: Light grey per specification MIL-E-15090B

TCE-20HC CALIBRATION UNIT

1. Calibration: adjusts and calibrates up to 200 channels
2. Readout: visual on any data channel
3. Calibration accuracy: $\pm 0.6^{\circ}\text{F}$
4. Ambient temperature range: $+20^{\circ}\text{F}$ to $+120^{\circ}\text{F}$
5. Size and mounting: 5.25 x 19 inch panel for standard rack mounting
6. Finish: Light grey per specification MIL-E-15090B

*These specifications do not apply to Airborne Model

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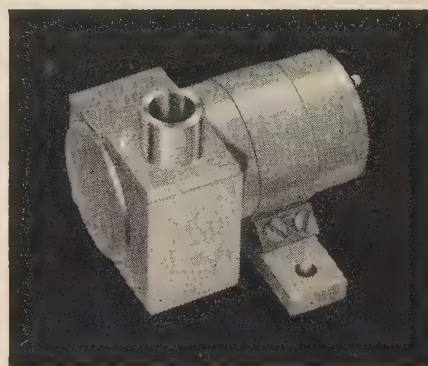
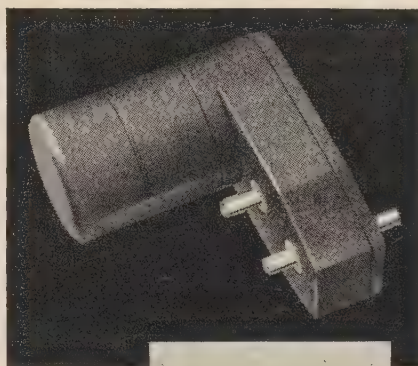
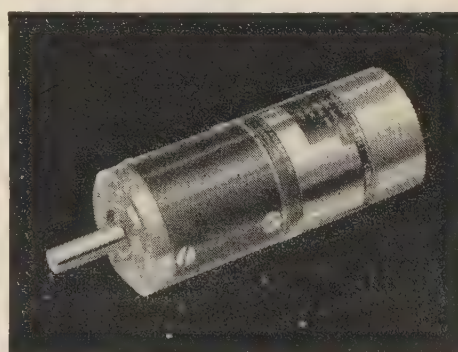
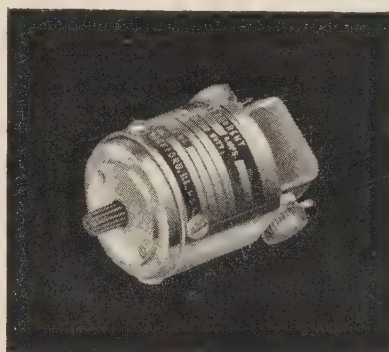
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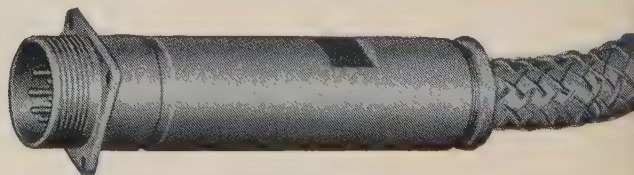
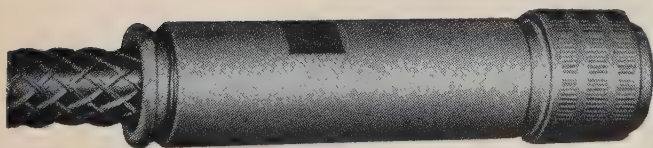
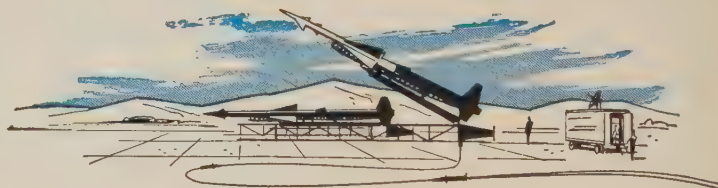
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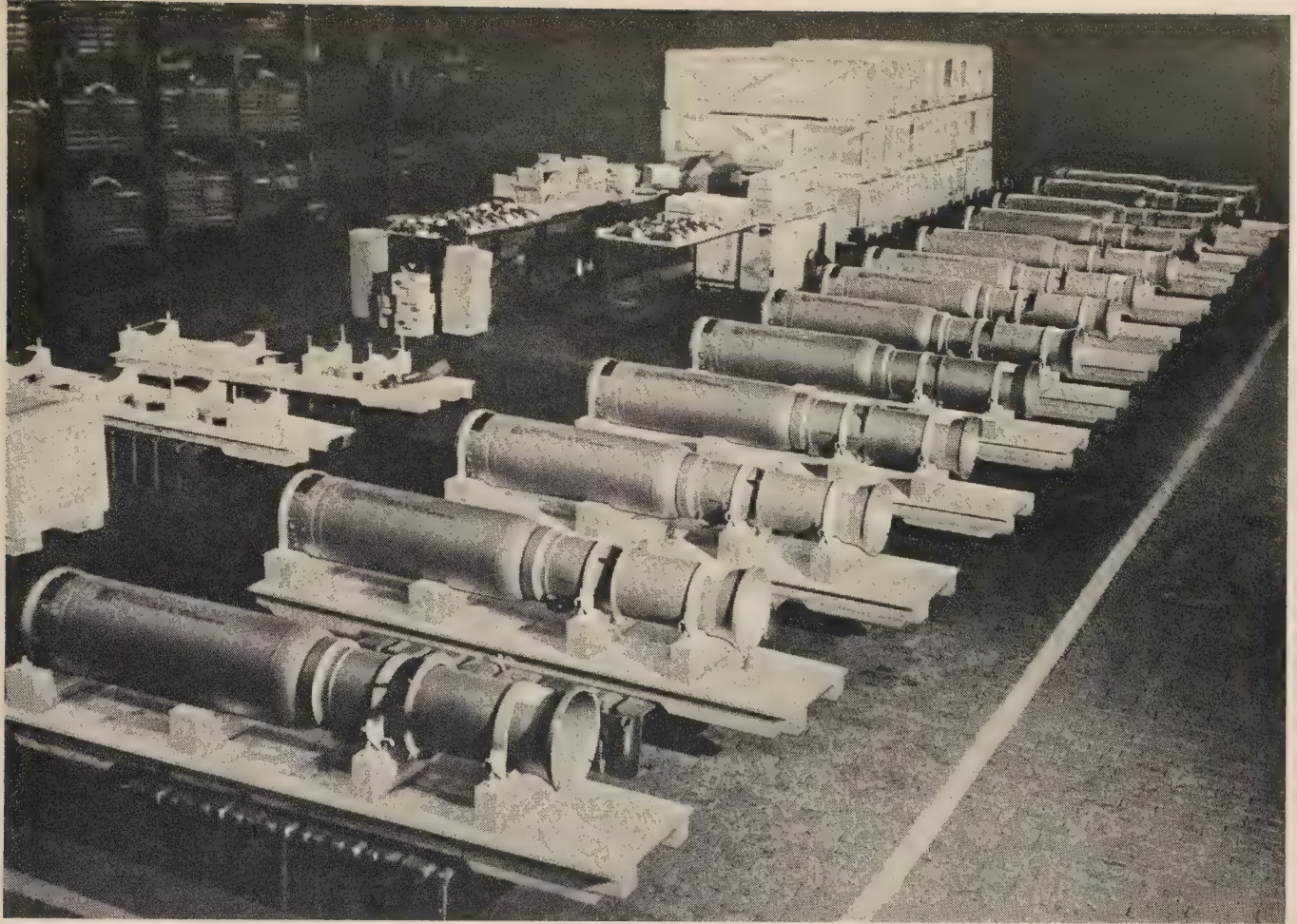
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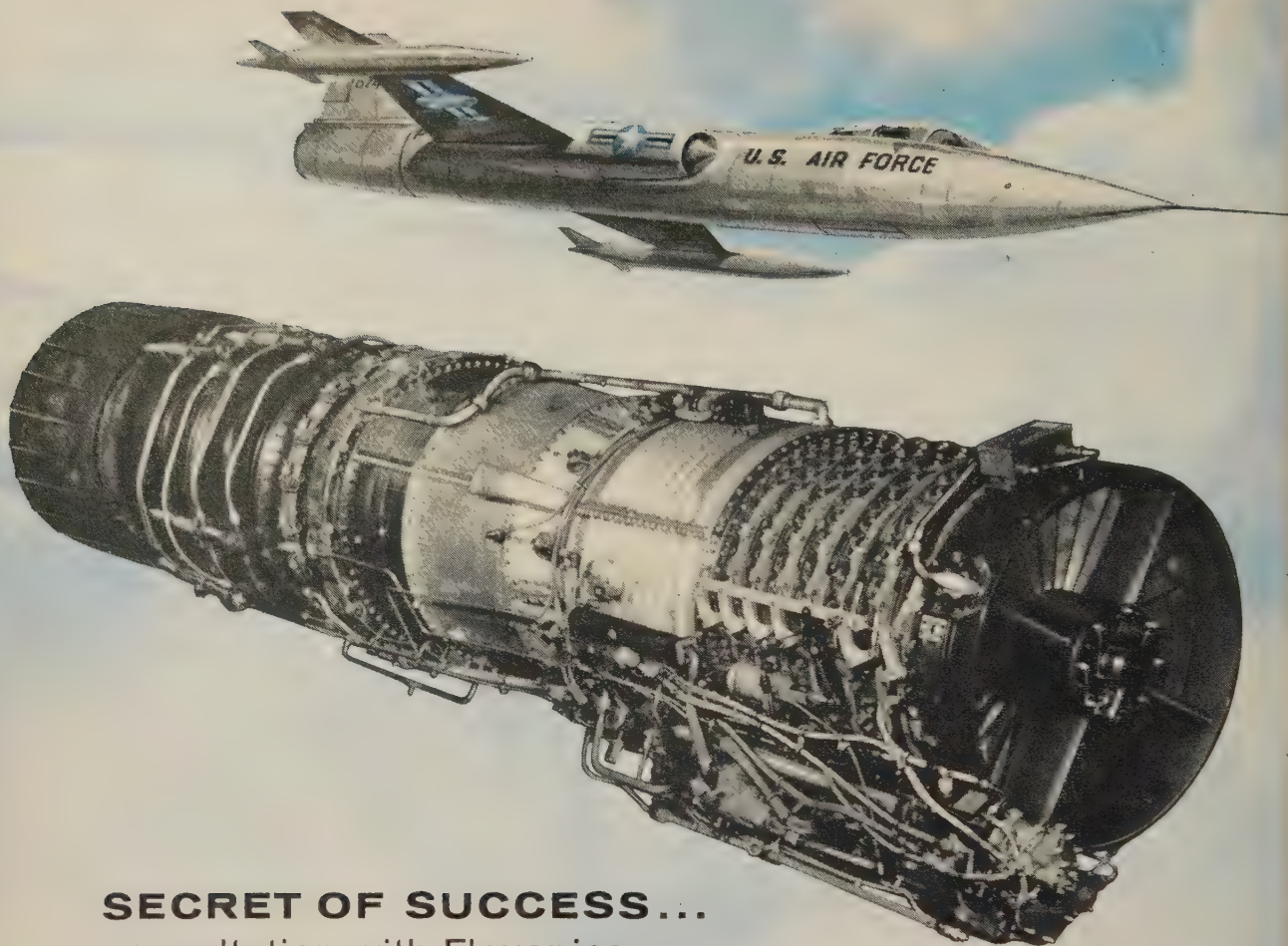


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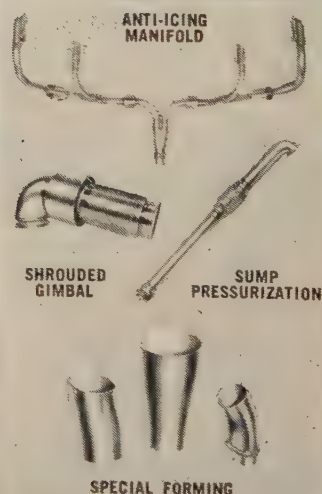


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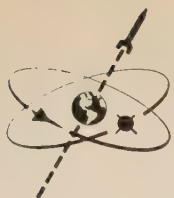
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SPACE/AERONAUTICS



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transients and compensates for changes in load.

The use of magnetic amplifier circuitry with tantalum capacitors, silicon diodes and rectifiers...coupled with inherent short circuit protection...combine to achieve a degree of reliability unattainable in other types of circuits.

SPECIFICATIONS:

Model 40-103-0 is a typical 5 watt supply used extensively in missile instrumentation:

Input/95-125 V; 380-420 cps

Output/4.75 to 5.25 V DC (Adjustable), 0 to 1 amp

Regulation/±0.1%

Ripple/0.5% rms max. at full load

For additional information on MRC's complete line of airborne power supplies, write for Data File PS 1000.

MAGNETIC RESEARCH CORPORATION

3160 West El Segundo Boulevard, Hawthorne, California

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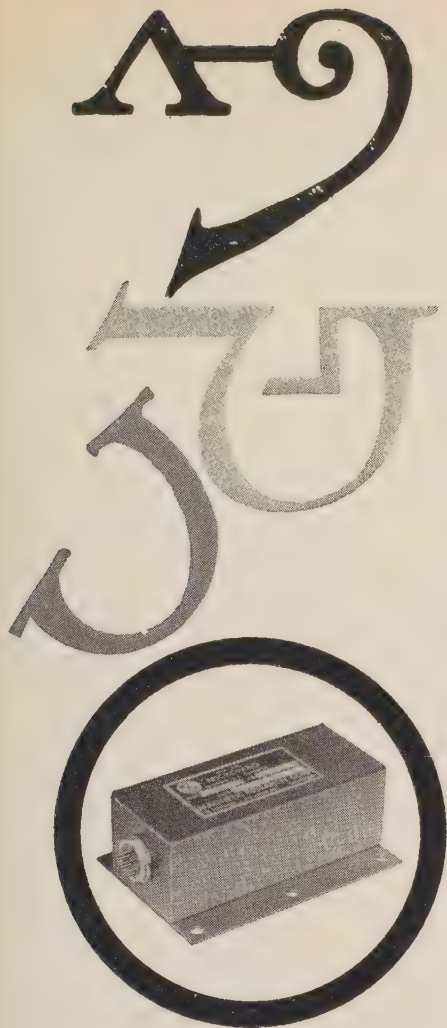
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MRC proudly presents another series of quality products equally recognized for dependability, and performance. The Micromag, a low-level drift-free magnetic DC amplifier, completely solid state... ideally suited for instrumentation applications where temperature, strain and pressure are to be measured. DC signals in the millivolt region are amplified to the 0 to 5 volts DC range required for telemetering and recording systems.

Typical Specifications:

- Power / 26-31 volts DC, 10 milliamps
- Input Signal / 0-10 millivolts DC
- Voltage Gain / 500 $\pm 10\%$
- Output Load / 100 K ohms
- Linearity / $\pm 2\%$
- Gain Stability / $\pm 3\%$ from 0°C to +65°C
- Common Mode Rejection / At DC, 10⁴
- At 60 cps, 10⁴
- At 400 cps, 10³

For additional information on MRC's complete line of Micromags, write for Data File No. MA1001.



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3160 West El Segundo Blvd.
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United Research Corporation of Menlo Park, a subsidiary of United Aircraft Corporation, announces it has changed its name to

UNITED TECHNOLOGY CORPORATION

Objectives of this company have evolved to encompass not only research but also development work in the fields of solid and liquid propellants through complete qualification of rockets and of advanced propulsion systems.

The new name — with its emphasis on "technology" — clearly defines the scope of the activities being undertaken.

Construction of two multi-million dollar permanent facilities to implement the objectives of the corporation is now underway. A Research and Engineering Center is being built on a 25-acre site in Sunnyvale; a Development and Test Center in the foothills some 10 miles south-east of San Jose, California, in the prime living area of the San Francisco Peninsula.

UNITED TECHNOLOGY CORPORATION

P. O. Box 365 • Menlo Park, Calif.

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Experience — the added alloy in Allegheny Stainless



What are your needs in Seamless Tubing?

A-L offers widest range of materials and large diameters with walls as thin as .032".

Here is the widest range in materials in stainless seamless tubing available anywhere to meet your exact requirements and solve high-temperature or corrosion problems and save you money.

Allegheny Ludlum makes seamless tubing in all stainless grades including 309, 317, 318, 310, 416 and 446—normally difficult to obtain. Also available in high-strength alloys such as A-286, in vacuum melted steels, and in custom analyses grades such as low cobalt with .01 or .05 max. and small boron additions to standard types.

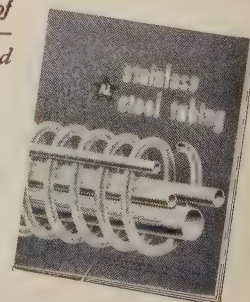
A-L also makes composite tubes with bonded combinations of carbon and stainless and other metals for special chlorine-corrosion applications in process equipment.

Allegheny Ludlum Stainless Tubing ranges from $\frac{3}{16}$ " OD to $3\frac{1}{2}$ " OD with wall thickness ranging from .013" to .375"—typical of the sizes that A-L can produce. For certain applications, .500" walls are possible. Some standard sizes in stock are $2\frac{1}{2}$ " OD—.032" walls, 3" OD—.042" walls and $3\frac{1}{2}$ " OD—.042" walls and $3\frac{1}{2}$ " OD—.058" walls. All sizes with true circularity, no dents or handling marks.

A-L Tubing is also available in small quantity orders, in random or cut lengths. Standard grades and sizes in stock throughout the country. Call your nearest A-L representative for all the help you need.

Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pa. Address Dept. AV-21

NEW! FREE—Write for your copy of Allegheny Ludlum Stainless Tubing—32-pages of technical data, grades and suggested applications.



WSW 7829

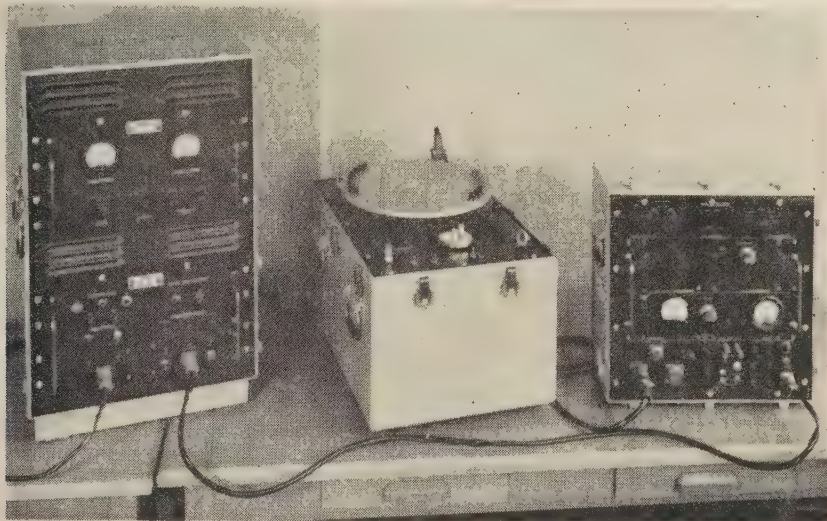
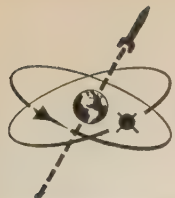


ALLEGHENY LUDLUM

Export distribution: AIRCO INTERNATIONAL

EVERY FORM OF STAINLESS . . . EVERY HELP IN USING IT

Write in No. 345 on Reader Service Card at start of Product Preview Section



GYRO TEST SET

A PRECISION test set for field calibration of rate gyros, rate gyro-amplifier-demodulator packages, and amplifier-demodulators is going into production at Boston Div., Minneapolis-Honeywell, 40 Life St., Boston 35, Mass. Developed under contracts with Convair-San Diego and USAF, it will give Air Force technicians in the field a "foolproof" test device for complex gyro packages in advanced aircraft. M-H says the unit can be used by personnel with a minimum of training.

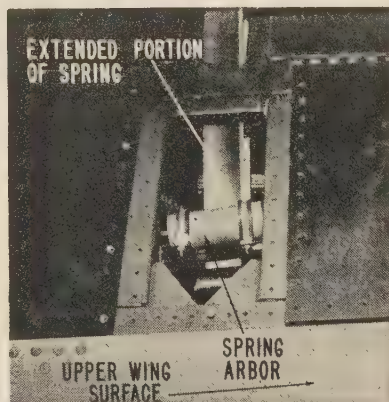
With only minor engineering mods, the field test set can check out individual gyros very precisely. The complete unit is made up of three units:

- a calibrator for precise mea-

surement of electronic system characteristics like null voltage, output sensitivity, linearity, resolution (in deg/sec), ac ripple (in mv RMS), dc null (in mv), and ac null (in mv RMS);

- a regulated power supply with an output of $115\text{ V} \pm 1.5$ per cent (no load to full load), 400 cps ± 0.1 per cent with less than two per cent harmonic distortion, requiring an input of $115\text{ V} \pm 5$ per cent, 400 cps ± 5 per cent, single-phase excitation of about 1500 W;

- a rate table with a 1-120-deg/-sec range and a resolution of 0.03 deg/sec that uses a mounting fixture suitable for a wide range of gyros and gyro packages. Write in No. 56 on Reader Service Card for more information.



WING SLAT CONTROL

TO provide increased lift at certain positive angles of attack and low speeds, the Navy's Martin P6M SeaMaster uses wing slats whose motion is controlled by the aerodynamic forces on the wing. During normal flight, the slats retract against the wing.

The force required to hold the slats in the retracted position is provided by "Neg'ator" constant-force springs from Hunter Spring Co., Lansdale, Pa. Two Neg'ator springs are attached to a slat. Each exerts a constant force of 32 lb on the slat through its travel. This provides the nominal "hold-closed" force for keeping the slat retracted during normal flight.

The springs are prestressed bands of spring steel that normally form a tight coil. The uniform-load feature lets the slats move smoothly away from the wing at aircraft altitudes for which the sum of the forces acting on the slats in the forward direction is greater than the force of the spring. The absence of the usual buildup of spring force provides for greater slat control. Since the Neg'ator springs furnish full force at all extensions, complete retraction is assured during normal flight.

The fixed end of the Neg'ator spring coil is attached to a freely rotating drum mounted in the wing. The free end of the spring is attached to the movable slat. The extended portion of the spring is supported by the slat track. Write in No. 70 on Reader Service Card for more information.

"PLIERS" SPOT HOT LEADS IN HARNESSES

MANUFACTURING research engineers at Boeing Airplane Co., Wichita 1, Kan., have designed a portable current-path verifier to isolate current-carrying leads in multi-conductor harnesses. Boeing is using the verifier to speed up inspection of B-52G harness installations. Since the unit is compact and has no power supply leads, it can be used in confined areas.

The five-pound tester is powered by two small dry-cell batteries. It has a hinged iron element, or test probe, that opens and closes like a pair of pliers. This element is wound with a multi-turn coil. When the unit is closed around a "hot" wire, a voltage is induced in the coil. This voltage triggers a CK5643 miniature thyratron tube to light a small neon lamp.



TURBINE DRIVES UNLIMITED

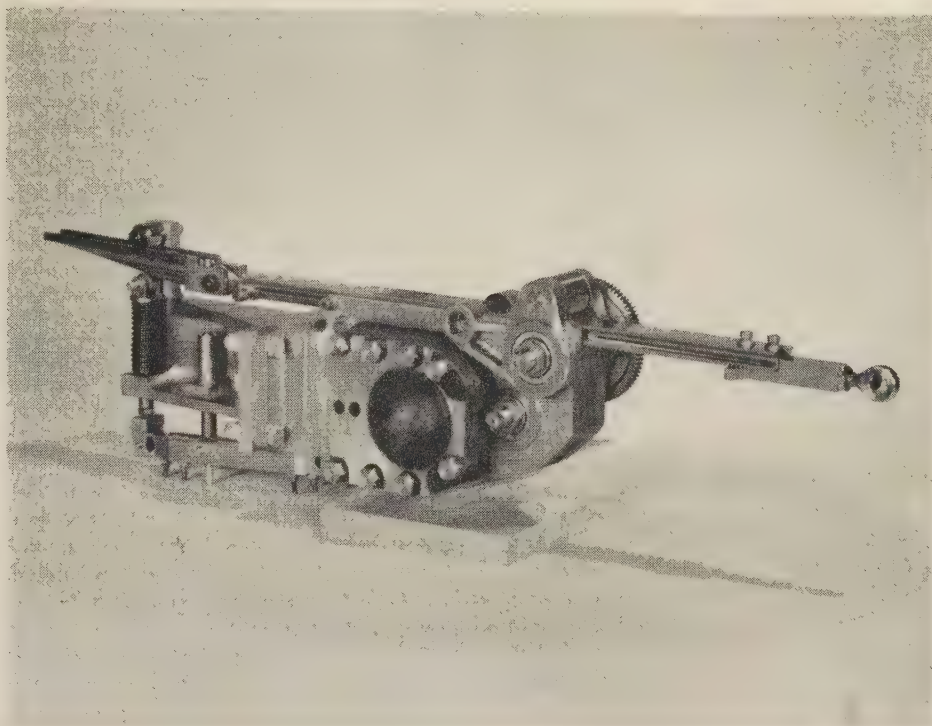
FOR THE WHO'S WHO OF TURBINE INDUSTRY

WESTERN GEAR SUPPLIES PRECISION MINIMUM-WEIGHT, HIGH-SPEED TURBINE DRIVES RATED TO 10,000 HORSEPOWER TO AEROJET • AIRESEARCH • BELL • BOEING • CHANCE-VOUGHT • CONVAIR • DOAK AIRCRAFT • DOUGLAS • GENERAL ELECTRIC • GRUMMAN • KAMAN • MCDONNELL • NORTH AMERICAN • PRATT & WHITNEY • REPUBLIC • RYAN • SOLAR • WALTER KIDDE.

Distinguished names like these—the leaders of the industry—have set the pace for turbine development—and keeping pace with them is Western Gear with the precision gear drives that add to turbine efficiency. In the belief that we have produced more drives than any other manufacturer, Western Gear confidently offers the services of the field's most experienced engineers—experts in design whose work is backed by unmatched manufacturing and testing facilities. Simplify your own drive problems by calling on Western Gear—decades of experience and hundreds of designs to draw on can save you both time and money. We guarantee a better, completely reliable drive in less time. Let us prove it—call on Western Gear now. Call or write Precision Products Division, P.O. Box 192, Lynwood, California.



WESTERN GEAR CORPORATION



PNEUMATIC SERVO ACTUATOR for use at high temperatures



APRIL 1960

Controls & Accessories Div., Marquardt Aircraft Corp., Van Nuys, Calif., has developed a high temperature pneumatic servo actuator designed for extreme temperature and radiation environments. It has undergone severe endurance testing for 42 consecutive hours at up to 1600 deg F, says Marquardt.

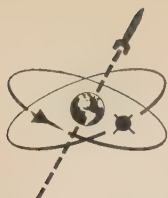
Featuring fast response coupled with advanced pneumatic servo valve and stabilization

techniques, the actuator is suitable for aircraft, missile, and nuclear control systems. Typical applications include rocket thrust vector controls, aerodynamic controls, and reactor servicing machinery and control rod drives. The prime mover is an opposed pair of nutating-disc motors with a rack-and-pinion drive. The absence of complex valving and lubrication insures reliability and easy handling.

Write in No. 347 on Reader Service Card at start of Product Preview Section

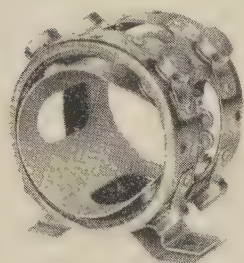
This award is made in recognition of outstanding service performed through the development and manufacture of a product contributing to the advancement of the aerospace industry.

Randolph Hawthorne
Editor



product preview

RADIAL MOUNTINGS for airborne instruments



This all-metal mounting is designed for airborne instruments which are not installed on the instrument panel. Models K710 utilizes a radial cushion design in which the resilient elements have been positioned to provide effective vibration and shock protection from all directions, according to Robinson Technical Products Inc., Dept. S/A, Teterboro Air Terminal, Teterboro, N. J. The high inherent damping and non-linear characteristics of resilient elements result in mounting systems capable of providing the high levels of protection necessary in supersonic aircraft and missiles.

Stainless steel cushions are unaffected by oil, water, dust, ozone, atmospheric pressure and extremes of temperature.

Write in No. 536 on Reader Service Card

SERVO AMPLIFIER is 4½ in. long

This servo amplifier is a magnetic amplifier package 4½ in. long and weighs ten ounces. The hermetically sealed device provides a push-pull dc outlet for proportional control of hydraulic transfer valves used in missile and aircraft flight control systems. It is a wide band pass servo unit especially designed to drive standard servo valves as made by Moog, Bendix-Pacific and Cadillac-Gage, says Vickers Inc., Dept. S/A, 1815 Locust St., Louis 3, Mo.

The amplifier, it is claimed, has a special low emissivity finish for extremely high radiant energy levels; has been qualified and meets mechanical and environmental specifications of MIL-E-5272A; provides for two control inputs (one may be feedback). Input range is +1 V, maximum output +15 ma and +15 V. Gain may be adjusted externally.

Write in No. 537 on Reader Service Card

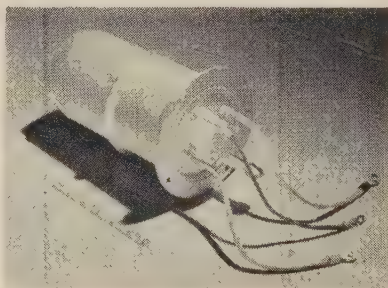
SPECTRUM ANALYZERS have high resolution

A line of real-time Simoramic spectrum analyzers synthesize the equivalent of thousands of bandpass filters located side by side in the frequency domain through the use of a single delay line in a well controlled closed loop. The Model 4A Analyzer covers the frequency band 1 cps to 200 cps with approximately 1 cps resolution, says Federal Scientific Corp., Dept. S/A, 615 W 131 St. New York 27, N.Y.

The output of the individual synthesized filters are presented sequentially for either human observation or computer consumption.

Write in No. 538 on Reader Service Card

THYRATRON for pulse modulators



Type GL-7390, ceramic hydrogen thyatron, is designed for high-power radar pulse modulators. The tube features increased power handling capabilities and smaller size, says General Electric Co., Dept. S/A, Schenectady 5, N. Y.

The tube has a peak anode voltage and current of 33 KV and 2000 amp. It is only 6 in in dia, and 12½ in long.

Write in No. 539 on Reader Service Card

MASS FLOW METER is miniature

A unique feature of this flow meter is a transmitter that incorporates only two moving parts. Its small size, weight, and low price makes it practical for use in small aircraft, says General Electric Co., News Bureau, Dept. S/A, Schenectady 5, N.Y.

Normal range involves flow rates of up to 1200 pph. However, simple modification can extend the range up to 1800 pph or 2400 pph. Since the flowmeter transmitter provides its own frequency regulation, frequency variations in the aircraft power system will have no effect on accuracy.

Write in No. 540 on Reader Service Card

BELLOWS are miniature



These micro-thin bellows assemblies, called "Mech-Metal," have wall thicknesses ranging from less than 0.003 in to over 0.003 in. Bellows resilience allows the cylindrical models to be safely subjected to 50 per cent compression and up to 100 per cent extension of original free length, says Mechtronics, Dept. S/A, 11431 Joanne Place, Culver City, Calif. Pressure differentials and deflection displaces provide such characteristics as 1/300 psi to 10,000 psi pressure range and 0.005 in to over 1.0 in deflection.

Basic properties, it is said, include a tensile strength of 240,000 psi, a yield of over 200,000 psi, modulus of elasticity of 30x10⁶, a temperature range of from less than -320 deg F to + 300 deg F and a co-efficient of thermal expansion of 7.6x10⁻⁶.

Write in No. 541 on Reader Service Card

CONTROLLER has radical design

Unique weight and size advantages have been designed into a new aircraft positioning and temperature controller, which operates standard dc electric valves or positioning actuators says AiResearch Mfg. Div., The Garrett Corp., Dept. S/A, 9851 Sepulveda Blvd., Los Angeles 45, Calif. The unit, a proportional pulse modulating control, uses silicon controlled rectifiers as the output device.

Volume is 28 cu in and weight is 1.1 lb. Design of the device makes possible an actuator speed approximately proportional to the magnitude of the signal. The controller requires a 115-V, 400-cycle input, and it tolerates a wide range of frequency and voltage. It will operate over a -65 to +250-deg F ambient range.

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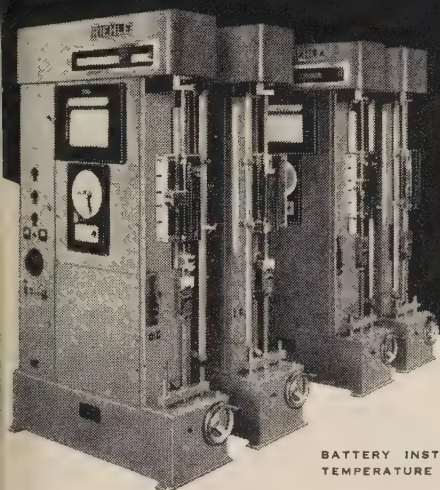
more on page 238

FROM RIEHLE

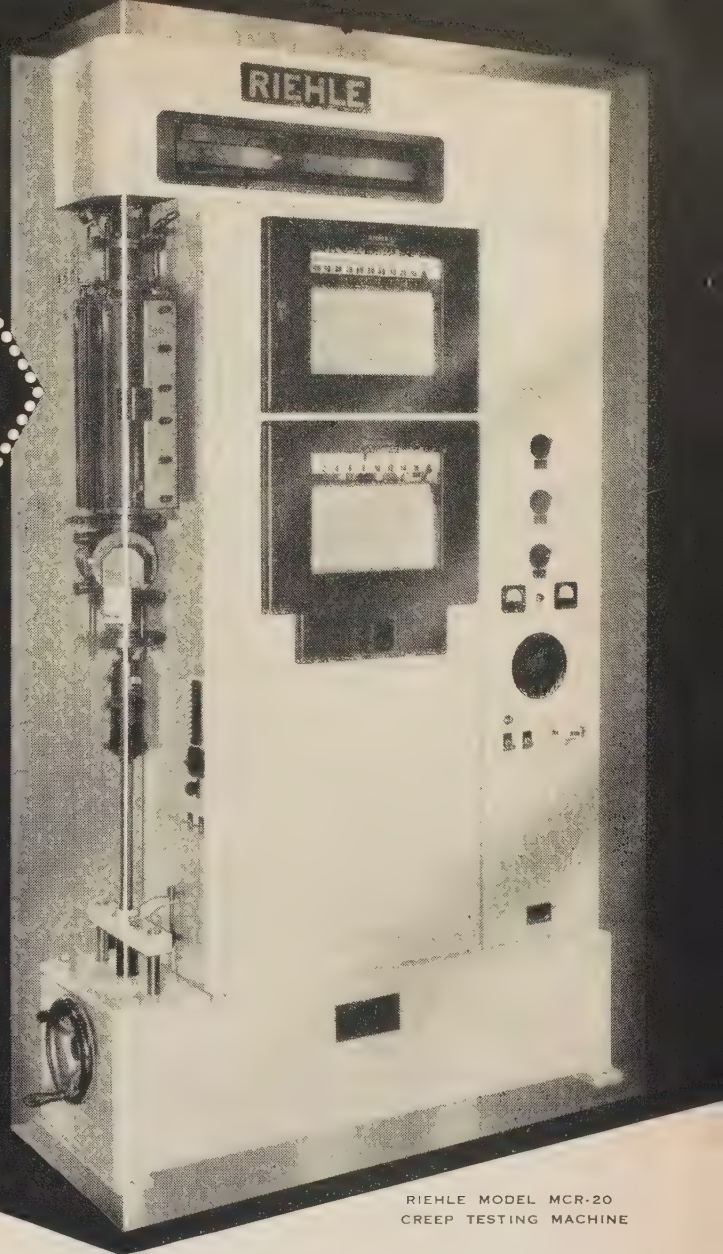
the complete package

FOR HIGH TEMPERATURE CREEP AND RELAXATION TESTING

including full instrumentation for
wide range of testing applications



BATTERY INSTALLATION OF RIEHLE HIGH
TEMPERATURE CREEP TESTING MACHINES



RIEHLE MODEL MCR-20
CREEP TESTING MACHINE

Complete systems of equipment for testing physical properties of materials at temperatures as high as 4000° F can be obtained from ONE source — RIEHLE TESTING MACHINES.

These ready-to-operate systems include:

- BASIC TESTING MACHINE
- STRAIN MEASURING INSTRUMENTATION
- COMPLETE HIGH TEMPERATURE ACCESSORIES

Using only 33 $\frac{1}{3}$ lbs. of weights, this RIEHLE Model MCR-20 features a multiple lever loading system to provide testing loads in increments of 1,000 lbs. A sliding poise and beam graduated in units of 10 lbs. provide intermediate loads.

CREEP AND STRESS RUPTURE TESTING MACHINES • HYDRAULIC FATIGUE TESTING MACHINES • HYDRAULIC UNIVERSAL TESTING MACHINES • UNIVERSAL SCREW POWER TESTING MACHINES



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A DIVISION OF
American Machine and Metals, Inc.

EAST MOLINE, ILLINOIS

"One test is worth a thousand expert opinions"™

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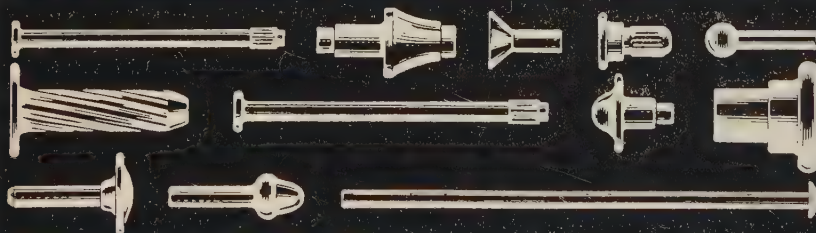


MINIATURIZATION

We are far into new areas with miniaturized and microminiaturized electromagnetic devices used in the Inertial Guidance systems we build. Our staff openings in miniaturization are for men who think big. Write to Mr. C. T. Petrie, Manager, Research & Engineering Staff.



LITTON INDUSTRIES Electronic Equipments Division
Beverly Hills, California



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Here is a fast, dependable, low cost, quality minded source of supply for JOB-DESIGNED fasteners of all types, in any metal, to fit your own assembly problem. Assembly costs are a very major part of manufacturing expense. Most of this is labor. The fastening medium itself is usually a minimum item. If a Job-Designed fastener makes assembly simpler and faster, permits the use of fewer fasteners, allows the designer functional freedom and improves product efficiency, yours is a specifying job well done. All these

possibilities are available when you come to Hassall for design assistance and quotation on challenging, difficult or unusual rivets, threaded nails, drive screws and other cold headed parts. Short or long runs, pilot quantities, engineering counsel, over 100 years of intimate association with cold heading—and a deep appreciation for the concept of value analysis—all are part of the Hassall service to you.

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PRODUCT PREVIEW

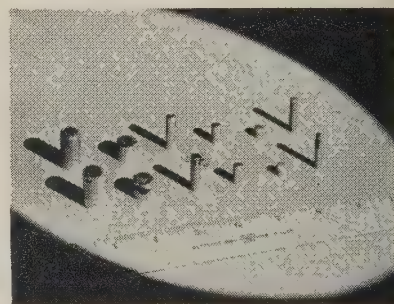
DICHROIC COATINGS allow color separation

Dichroic Coating is the generally accepted name for the family of coatings that reflect one portion of the spectrum and transmit another. Characteristically, these coatings are semi-transparent, multi-layer, high efficiency, non-metallic, and angularly sensitive, says **Optical Coating Lab., Inc.**, Dept. S/A, 1035 Sebastopol Road, Santa Rosa, Calif.

Since the possible types and uses of the dichroic coating are almost unlimited, it is suggested that detail of requirements be sent to the manufacturer.

Write in No. 543 on Reader Service Card

GENERATOR ELEMENTS made from lead telluride



Successful operation of the elements in thermo-electric generators at hot junction temperatures of 1100 deg F for several years demonstrates the chemical stability of the binary compound and proves the existence of compatible contacting and mounting design. Generators built with the elements have delivered over-all efficiencies of 6 per cent or more, says **Minnesota Mining & Mfg. Co.**, Dept. S/A, 900 Bush Ave., St. Paul 6, Minn.

Calculated thermal efficiency at matched load conditions for the elements under a temperature differential of 1000 deg F is 7.85 per cent. The elements are available in six standard sizes.

Write in No. 544 on Reader Service Card

OSCILLOSCOPE features modular design

Model K-160 oscilloscope is designed so that all signal generating and processing circuits are included in a single plug-in system. Several plug-in systems are available in order that sensitivity, bandwidth and other characteristics may be tailored economically to present needs, says **Electronic Tube Corp.**, Dept. S/A, 1200 E. Mermaid Lane, Philadelphia 18, Pa.

The main frame indicator consists of a 5 in single-gun cathode ray tube, its associated beam controls, identical X and Y main amplifiers, and a power supply capable of handling any future plug-in loads.

Write in No. 545 on Reader Service Card
more on page 242

Write in No. 349 on Reader Service Card at start of Product Preview Section

Write in No. 350 on Reader Service Card →
SPACE/AERONAUTICS

MOLECULAR ELECTRONICS

THE THIRD MAJOR BREAKTHROUGH in the history of electronics...

as significant today as the vacuum tube in 1907... as the transistor in 1948.

Molecular electronics use new insights into the structure of matter to create single crystals which perform one or more complete electronic functions in the control and transformation of energy.

Westinghouse can now report startling progress in this fantastic field—in this status report on a U. S. Air Force research program which began less than a year ago.

Fact one: molecular electronic systems are here today—in laboratory models which prove out the principle even as they pave the way for production models. On the next two pages are a number of different molecular electronic devices performing the functions of familiar systems, without conventional components.

Fact two: each one incorporates germanium or silicon crystals—etched, sprayed or alloyed.

Fact three: each one is a functional block which performs the missions usually requiring conventional components soldered together.

Prediction: soon, multi-zoned crystals will be “grown” and processed directly from the furnace melt—may emerge as ready-made electronic systems.

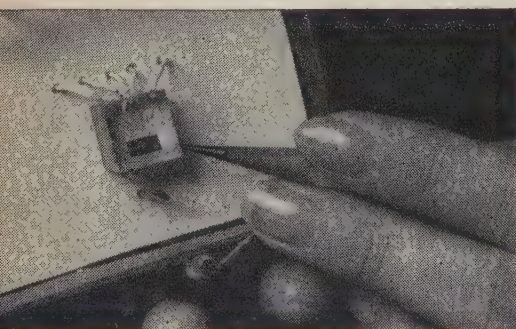
Prediction: only two to five years from now, the pattern of electronic systems will be changed to the core as a result of this historic Westinghouse breakthrough in research and development. Reliability, miniaturization and simplicity will show exponential progress.



Westinghouse presents working proof of the principle of molecular electronics



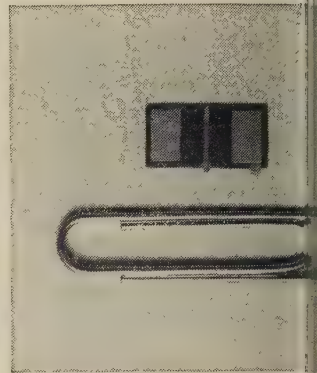
POWER AMPLIFIER: Button-sized molecular electronic device held by girl with a pair of tweezers performs the same amplifying function as a conventional 5-watt amplifier, has a frequency range from zero to 20,000 cycles. Working element is a block about as large as the head of a pin.



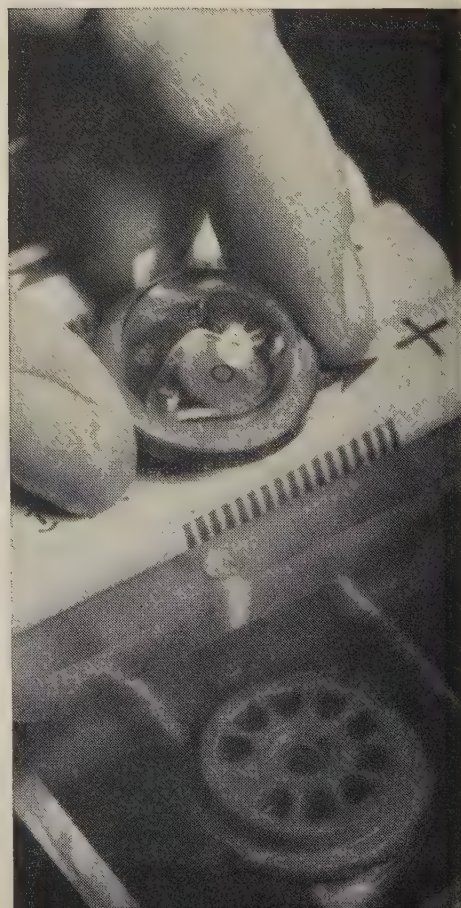
MULTI-POSITION SWITCHES: these molecular electronic devices evolved out of Westinghouse work on multivibrators—the “OR” logic switch illustrated has important potential applications in missile countdown functions.



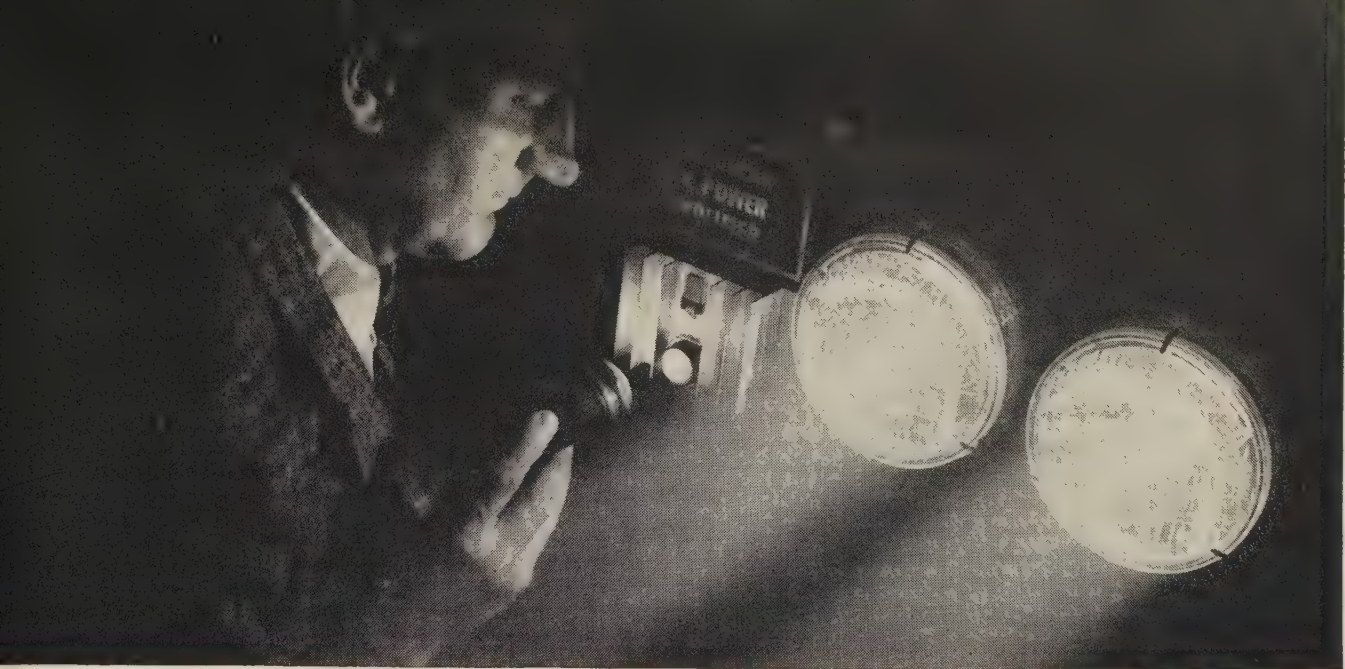
VIDEO AMPLIFIER: made with a tiny wafer from a ribbon of germanium crystal. This function block also works like a radar amplifier sub-system. Gain is essentially flat to frequencies of several megacycles.



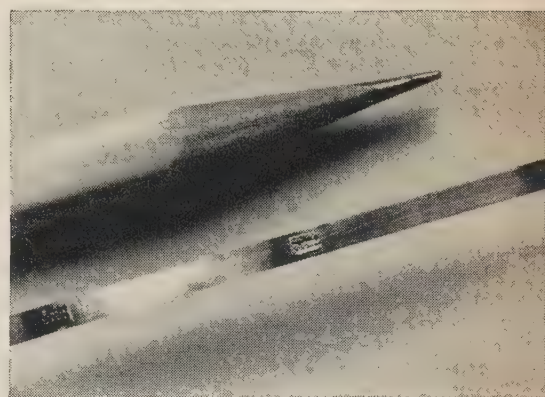
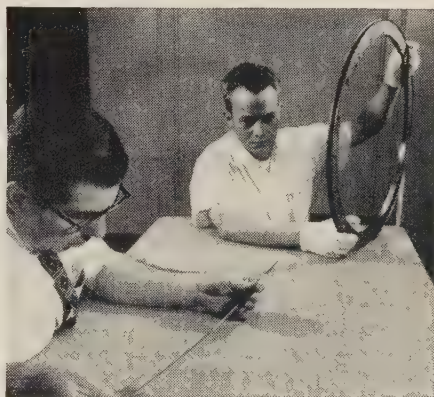
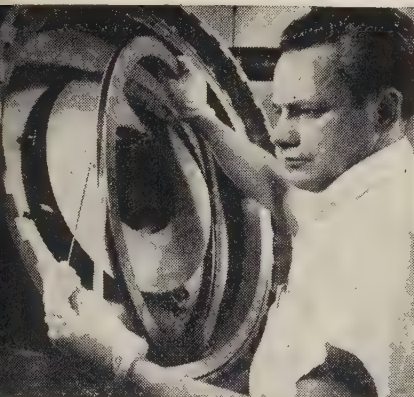
MULTIVIBRATORS: stable, monostable, astable—covering frequencies from 1 cycle less to 3 megacycles. Shown is a free running multivibrator along paper clip.



LIGHT TELEMETRY SUB-SYSTEM: a single light-responsive monolithic element delivers output whose frequency is a measure of light intensity.



CRYSTAL AMPLIFIER: connected to a solar cell, this tiny block takes an input of 4 milliamps . . . via flashlight beam, raises it to 40-watt output.



CRYSTAL GROWING techniques developed by Westinghouse have already produced germanium dendrites 300 feet long in the special furnace shown left, above. Crystal ribbons of almost any length are possible. The take-up reel at right holds 300 feet of the brittle dendrite with each turn cushioned in glass-cloth tape.

CRYSTAL RIBBON requires no grinding or lapping. Only a few steps are needed to turn these "educated" crystals into working electronic systems. Above, multiple-junction systems are shown on a crystal section.

The meaning of molecular electronics

RELIABILITY: molecular systems reduce drastically the number of components and internal connections required—and the fewer components and connections the fewer potential trouble spots.

MINIATURIZATION: molecular electronic systems are less than one-thousandth the volume and weight of conventional component systems. This is a conservative generalization—in many cases, much more startling size and weight reductions are possible.

POWER REQUIREMENTS: input power can drop almost as fantastically as size and weight. In a typical light telemetering sub-system, a 5-watt input is required; the transistorized version gets by with 0.75 watts. The same function is still performed by a molecular electronic block requiring but 0.06 watts.

ENVIRONMENT: inherently more resistant to g-loads because of their small mass and few components,

Westinghouse-developed molecular systems show promise to be temperature and radiation resistant as well. New semiconductor materials and new large crystal surfaces point to very high temperature and power-handling capabilities.

FUTURE: progress in this new field is so rapid, and the advantages so great, that the molecular electronics concept will find wide applications in air/space electronic systems within 3-5 years . . . In particular, look for great advances in the state of the art in these areas: telemetering • fire control guidance • communications • counter weapons • flight control—as a direct result of the new molecular electronics era.

The Air Arm Division of Westinghouse Electric Corporation holds the U. S. Air Force management contract for this project. It is being supported by the Semiconductor Department, the Materials Engineering Department, and the Westinghouse Research Laboratories.

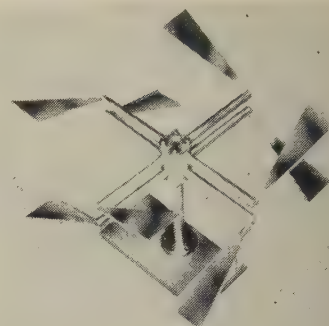
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WESTINGHOUSE / DEFENSE PRODUCTS

1000 CONNECTICUT AVENUE, N. W., WASHINGTON 6, D. C.

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TELEMETRY ANTENNA is circularly polarized



This omnidirectional telemetry antenna features coverage over the 216 to 260 Mc frequency range and operates equally well for transmitting and receiving. Pattern is similar to quarter wave stub, except circularly-polarized. Impedance is 51 ohms and VSWR less than 2 to 1, says Dynatronics, Inc., Dept. S/A, Box 2566, Orlando, Fla.

The antenna is suited for both ground and airborne application. For airborne use, it is normally supplied with a fiberglass radome of 1/8 in thickness.

Write in No. 532 on Reader Service Card
more on page 244

KLYSTRON

To electrically and mechanically design and develop broadband and super high power Klystron tubes.

TRAVELING WAVE DEVICES

To join a development team on high and low powered Traveling Wave Tubes and Carcinotrons.

CROSSED FIELD DEVICES

To perform advanced research on Crossed Field Amplifiers.

BARRATRON®

To carry on development work on this new and unique microwave product.

MAGNETRON

To perform unique design work in both the CW and Pulse type tube areas.

Openings exist in these product line areas for Junior, Intermediate, and Senior level engineers.

MICROWAVE TUBE ENGINEERS

If you qualify for any of these positions, please contact Mr. Thomas S. Fike, 960 Industrial Road, San Carlos, California.



LITTON INDUSTRIES

Electron Tube Division
San Carlos, California

CLOSURES

- Metal or Plastic Caps or Plugs to protect threads, tubes, machined parts, reamers, cutters, tools.
 - Protect against thread damage, dust, dirt, and moisture.
 - For inside and outside application.
- All sizes. Immediate delivery.

Clover closures are made in metal and tough plastic polyethylene. They are made in caps, plugs and special shapes to fit parts tightly, offering completely sealed protection during manufacture, shipping and storage. Backed by years of closure experience. Write for low prices and complete information.

Send coupon today!

Gentlemen: Please send samples and prices of closures in Polyethylene ☐ Aluminum ☐

Name.....

Address.....

City.....



CLOVER INDUSTRIES, INC.

602 Young Street
Tonawanda, N. Y.

Write in No. 355 on Reader Service Card



METAL Caps to cover AN & SAE threads



PLASTIC tapered caps and plugs



METAL plugs for AN & SAE threads



PLASTIC tube cap for AN & SAE parts

connectors

Lighter weight, smaller packaging, rugged construction, plus the ability to perform dependably under extreme environmental conditions, are all-important features of Harco thermocouple connectors. A perfect material match to other thermocouple circuit elements, Harco connectors successfully avoid signal interpretation errors and loss.



High temperature resistant connectors . . . quick disconnect sockets and plugs for all standard calibrations . . . a full range of shell styles and contact arrangements.

Harco designs special connectors to meet your individual needs.



Write today for free technical literature and the name of your local Harco Factory Representative.

HARCO LABORATORIES, INC.

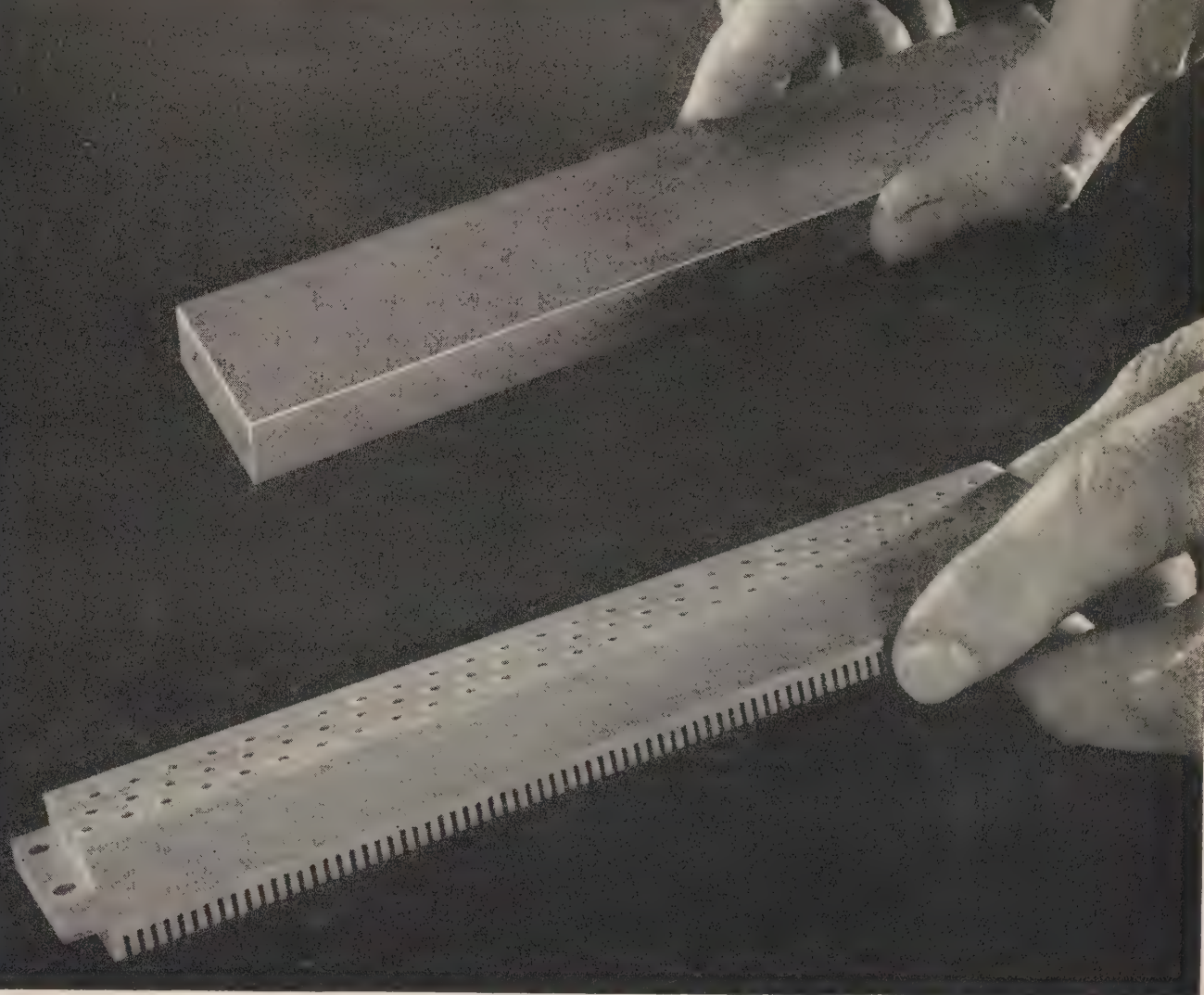
82 Olive Street, New Haven, Conn

Write in No. 389 on Reader Service Card

SPACE/AERONAUTICS



Synthane makes and fabricates laminated plastics



Why worry about fabricating laminated plastics? That's our job.

There is not much point to fabricating laminated plastics in your own shop. And there are good reasons why. One is the material itself.

Synthane laminates are available in sheets, rods, and tubes, and in over 33 standard grades. Choice of form and grade for your part is important. For example, a part which is basically tubular may have to be

cut from a sheet rather than a tube. Or the material itself may have to be modified in order to meet your requirements.

When you do your own machining, responsibility rests finally with you. The possibility of errors in dimensions, machining and tolerances, and of waste and delay suggest that you buy your laminated plastics from us

and let us do the fabricating for you. Call any of our representatives—in principal cities—for a quotation or get in touch directly with Synthane Corp., 55 River Road, Oaks, Pa.

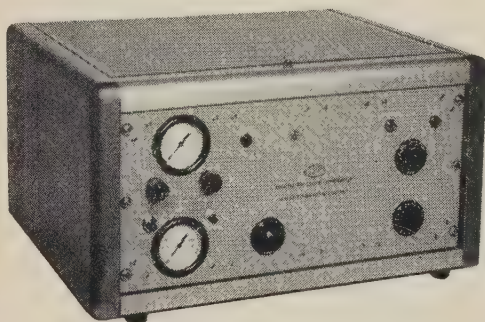
SYNTHANE
CORPORATION **S** OAKS, PENNA.

Sheets • Rods • Tubes • Fabricated Parts
Molded-laminated • Molded-macerated

You furnish the print . . . we'll furnish the part

Write in No. 356 on Reader Service Card at start of Product Preview Section

BREAKTHROUGH IN THE SCIENCE OF PRESSURE CONTROL



*digital-servo
reliability
crystal-determined
accuracy*

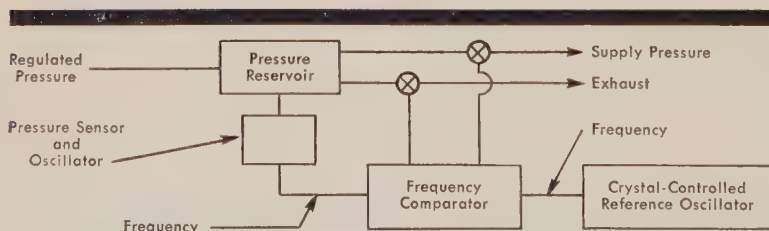
WIANCKO'S Q3700 SERIES DIGITAL PRESSURE GENERATOR

This system, employing unique digital-servo concepts, provides instant selection of a pneumatic pressure accurate to ± 0.05 PERCENT.

Pressure in a reservoir is measured and converted to a precision frequency. This frequency is compared with a selected reference frequency. If the frequency from the pressure sensor is high with respect to the reference frequency, the comparator produces a difference frequency in the form of pulses. These pulses then drive momentary exhaust valves until the pressure drops to the pre-selected value. When the frequency is low, error signals are produced which operate momentary pressurizing valves. The Q3700 is the best answer yet to pressure control and calibration problems.

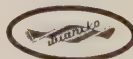
Ideal for:

- Programming precision pressure/time functions
- Automatic end-to-end calibration of data and telemetering systems
- Rapid calibration of pressure devices
- Ground checkout of instrument and control systems



For complete information please request Product Bulletin 111

WIANCKO
ENGINEERING COMPANY



Precision with lasting reliability

255 North Halstead Avenue • Pasadena, California

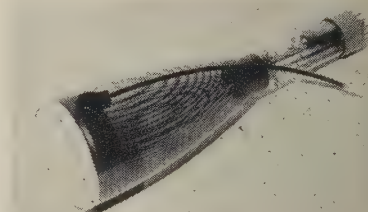
RESISTOR ALLOY has high resistivity

Alloy 815-R exhibits a resistivity of 815 ohms/cm at 20 deg C and a low temperature coefficient of resistance. The coefficient of resistance is inherently controlled within guaranteed limit of ± 0.00001 ohm/ohm/deg C (± 10 ppm), says Hoskins Mfg. Co., Dept. S/A, 4445 Lawton Avenue, Detroit 8, Mich.

Primarily intended for use in the manufacture of precision wire-wound resistors and potentiometers, the material is available precision drawn to standard wire sizes ranging from 0.0031 in down to 0.0005 in either bare or insulated.

Write in No. 533 on Reader Service Card

CATHODE RAY TUBE for hf oscilloscopes



Type K1546, high-writing rate CRT offers writing rates of 1.2 cm per millimicrosec that can be photographed on 35 mm super xx film with a lens setting of F 1.5 and an image reduction ratio of 4.2:1. A trace density of 0.1 above film fog is achieved when developed in D-19 developer for 26 min at 68 deg F, says Allen B. Du Mont Lab., Inc., Dept. S/A, 750 Bloomfield Ave., Clifton, N. J.

The tube was developed to record single millimicrosec transients. It features linear post acceleration for low pattern distortion and high deflection sensitivity.

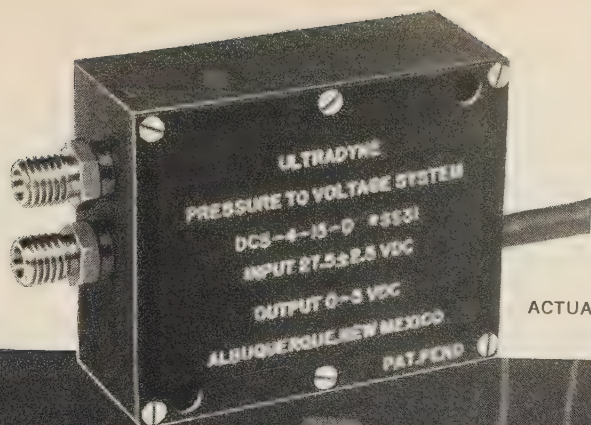
Write in No. 534 on Reader Service Card

UHF COMMAND RECEIVER for missile guidance

Model 2610 Command Receiver operates with an input voltage of 28 V dc at a pre-set frequency in the range of 400 to 450 Mc. Other specifications include frequency modulation ± 350 Kc at 50 cps to 15 Kc; sensitivity 7.5 microvolts for 6 db signal plus noise to noise ratio with 15 Kc audio bandwidth, says R S Electronics Corp., Dept. S/A, 435 Portage Ave., Palo Alto, Calif.

Unit is normally used with RSE decoder to convert audio information into ON/OFF or progressive commands. The receiver measures $2 \times 7\frac{3}{4} \times 2\frac{5}{8}$ in and weighs 2.5 lbs. Modified versions are available to meet physical or electrical needs.

Write in No. 535 on Reader Service Card
more on page 247



ACTUAL SIZE

Pressure to DC Voltage With Only One Moving Part



**ANY RANGE FROM 0-.1 psi to 0-3500 psi • FULL SCALE
OUTPUT 0-5 VOLTS DC • AVAILABLE NOW**

A stiff metal diaphragm is the only moving part in the new Ultradyne DCS-4, a complete DC/DC pressure transducer package. Because of its simplified design, this system withstands the most severe vibration and shock. It is especially suited for aircraft, nuclear, missile and other rugged applications.

The unit operates from standard unregulated 28-volt DC power supplies. Its full scale output of 0-5 volts DC can be fed to voltage controlled oscillators, DC computers or other DC-input system. DC output remains constant ($\pm 1\%$) despite input changes within the standard 25 to 30 volt range.

The DCS-4 offers all the advantages of a variable-reluctance transducer without the disadvantages of AC transmission. Advanced solid state circuitry eliminates amplifiers and their drift problems. The DCS-4 uses a regulated transistorized multivibrator working into a completely passive circuit.

The new Ultradyne DCS-4 is available now in any range from 0-.1 psi to 0-3500 psi in gage, absolute or differential pressure types.

Send for complete specifications and application data.

- pressure ranges — 0-.1 psi to 0-3500 psi
- power supply — standard unregulated 28-volts DC
- frequency response — designed to pass intelligence frequency of IRIG band E (at least 2100 cps)
- output voltage — 0-5 volt DC, full scale
- output regulation — constant within $\pm 1\%$ with input ranging from 25 to 30 volts DC
- operating temperature — -85°F to $+212^{\circ}\text{F}$
- size — $2" \times 2\frac{1}{2}" \times 1\frac{1}{16}"$
- weight — 9 ounces (less fittings)

ULTRADYNE
INCORPORATED
P.O. BOX 3308 ALBUQUERQUE, NEW MEXICO



A Member
of The
Condec Group

ULTRADYNE INCORPORATED
P.O. Box 3308, Albuquerque, New Mexico. Dept. SA-4

Gentlemen:

I want to know more about the new Ultradyne DCS-4 DC/DC pressure-to-voltage system. Please send me complete specifications and application data.

NAME.....

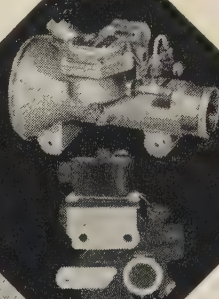
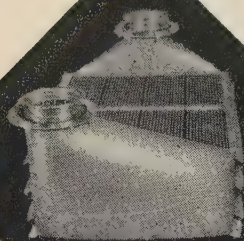
COMPANY.....

ADDRESS.....

MY TITLE OR JOB POSITION IS.....

Write in No. 351 on Reader Service Card at start of Product Preview Section

compact heat exchangers of
conventional or platular design
for heating or cooling



precision pneumatic controls
for bleed-air combine functions
saving weight and space —
special control specs invited

air duct couplings and
supports in sizes up to 36"
feature metal-to-metal seal, quick
disconnects, maximum safety



For a proposal you can rely on
contact your Janitrol engineering
representative when your plans call
for components, pneumatic sub-systems,
and complete systems for heat transfer
and air control. Virtually every modern
aircraft and operational missile incorporates the
skills that Janitrol translates into practical
hardware. Janitrol Aircraft, a division
of Midland-Ross Corporation,
4200 Surface Road,
Columbus 4, Ohio

liquid heaters for ground
support equipment in compact
sizes to 1 million Btu/hr —
multi-fuel use

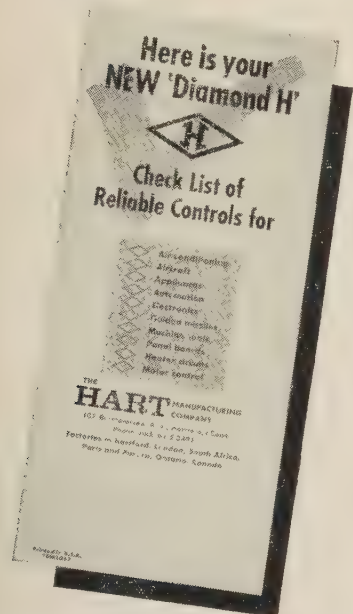
combustion systems include
hot fuel prime units, inert gas
generators and aircraft heaters



reliable components for missiles / aircraft / support

Write in No. 17 on Reader Service Card at start of Product Preview Section

***Yours for
the asking***



This "Diamond H"



**Checklist of
Reliable Controls**

... Relays, Thermostats,
Switches ... engineered to
meet your specific require-
ments in a wide variety of
applications including air
conditioning, appliances, air-
craft, missiles, machine tools,
panel boards, heater and mo-
tor control circuits, and many
others.

Ask also for our new applica-
tion data sheets on Series R
and Series W Relays, and
Rotary Switches.

THE HART
MANUFACTURING COMPANY
212 Bartholomew Ave., Hartford 1, Conn.
Phone JAcKson 5-3491

Write in No. 18 on Reader Service Card
April 1960

PRODUCT PREVIEW

**FREQUENCY STANDARD
is transistorized**

Model NC-1200, transistorized frequency standard, provides outputs of 0.1, 1.0, and 5.0 Mc, all stable to one part in 10^9 per day. All three outputs may be used simultaneously and each is capable of developing an output voltage of 200 mv across a 50 ohm load, says National Co., Dept. S/A, Malden, Mass.

The unit is designed for standard relay rack installation. The frequency is adjustable by means of a ten turn dial which permits calibration to one part in 10^{10} .

Write in No. 200 on Reader Service Card

**INSULATOR
has hollow body**



This feed-through insulator, known as series CF-405, features a hollow threaded metal body which fits through a bed plate and is secured by a hex nut. The entire insulator unit ranges from .690 in in length and has a rated capacitance of 2.00 mmfd., says Fluorocarbon Products, Inc., Dept. S/A, Camden 1, N. J. The terminal, which passes through its hollow body is spaced by a force-fitted teflon plug.

Teflon's insulating properties for high frequency, high temperature and high voltage service, coupled with its resistance to thermal and mechanical shock, insure maximum performance in the most severe applications.

Write in No. 201 on Reader Service Card

**FILTERS
for ground support**

This line of radio interference filters features construction and electrical characteristics of MIL-E-15733C filters. The unit is completely hermetically sealed while providing convenient stud-type terminals for standard electrical connectors, says Genistron, Inc., Dept. S/A, 2301 Federal Ave, Los Angeles, Calif.

The line includes single-and three-phase 120 V and 240 V, 60-400 cycle units in the current range of 5 to 100 amp rating.

Write in No. 202 on Reader Service Card
more on page 249

**BASIC
BUILDING
BLOCKS
FROM KEARFOTT**



**20 SECOND
SYNCHRO**

This synchro, just one of a broad line offered by Kearfott, provides the extreme accuracy required in today's data transmission systems. Kearfott synchro resolvers enable system designers to achieve unusual accuracy without the need for 2-speed servos and elaborate electronics. By proper impedance, matches up to 64 resolver control transformers can also operate from one resolver transmitter.

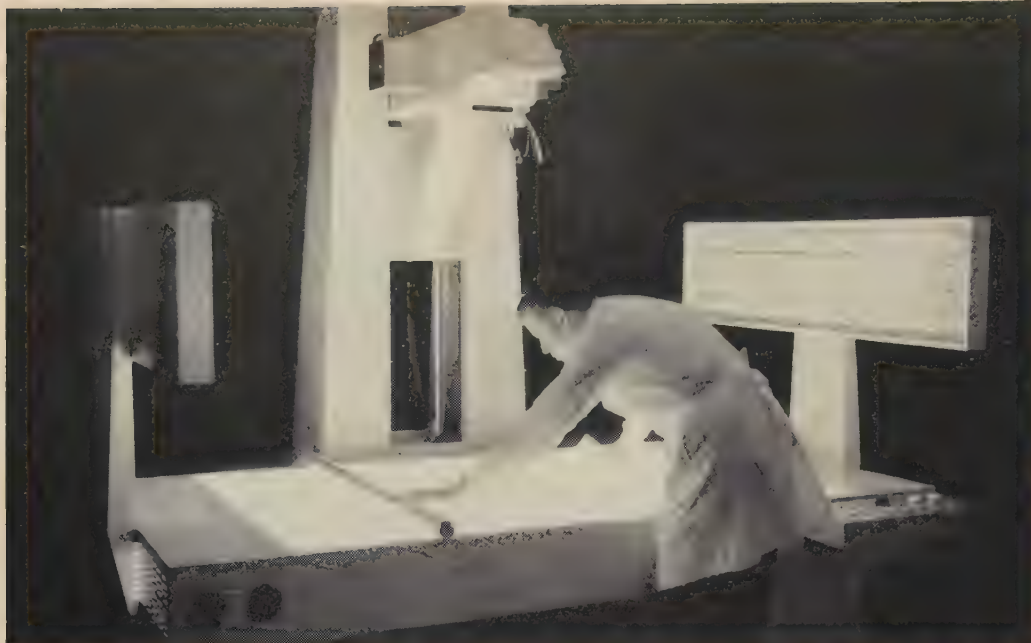
TYPICAL CHARACTERISTICS		SIZE 25
		Control
Type Resolver	Transmitter Transformer	
Part Number	Z5161-001	Z5151-003
Excit. Volts (Max.)	115	90
Frequency (cps)	400	400
Primary Imped.	400/80°	8500/80°
Secondary Imped.	260/80°	14000/80°
Transform. Ratio	.7826	1.278
Max. Error fr. E.Z.	20 seconds	20 seconds
Primary	Rotor	Stator

Write for complete data.



KEARFOTT DIVISION
GENERAL PRECISION INC.
LITTLE FALLS, NEW JERSEY

Write in No. 19 on Reader Service Card
247



MICRO-MASTER® 105/35mm Camera-Projector

A new K&E exclusive combines the two important miniaturization systems—105mm and 35mm—in a single, compact unit, permits tailoring of reproduction to the exact requirements of each job. Camera and projector are combined in a single overhead assembly with interchangeable magazines. Operator can shift from camera to projector, 105mm to 35mm, roll to sheet, film, black and white to color... in seconds!

KECOFAX® 105/35mm Projector-Printer

Now, for the first time, a unit that produces sharp, permanent, *work-size* electrostatic prints up to 34" x 48". From exposure to print in 40 seconds. Delivers as many as 19 prints automatically. Process completely eliminates wet processing. Direct exposure onto electrically charged paper forms a latent electrostatic image by dissipating charges in the light struck areas... passage through toning and fusing chambers forms and permanently fixes a visible image.



2 Dynamic

New Developments in Miniaturization of Engineering Drawing

**Maximum performance and flexibility
are yours in these new K&E units...**

Miniaturization takes on a new dimension with the introduction of these two new K&E units—the basic components of a complete reproduction system engineered by K&E to provide maximum speed, accuracy and *flexibility* in miniaturization of engineering drawings.

For use in conjunction with your present equipment, or as the foundation of a complete new system, the MICRO-MASTER 105/35mm Camera-Projector and KECOFAFAX Projector-Printer working together provide both 105 and 35mm negatives and all sizes of prints required from full-size to any reduced size. Incorporating dozens of outstanding engineering firsts, these units represent an entirely new concept in effortless, *full-range* miniaturization...

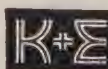
For further details on these new K&E units, and the complete line of MICRO-MASTER and KECOFAFAX miniaturization equipment, send us the coupon to the right.

KEUFFEL & ESSER CO., Dept. AA-4, Hoboken, N. J.

Please send me complete information on the ☐ MICRO-MASTER® 105/35mm Camera-Projector, ☐ KECOFAFAX® Electrostatic Projector-Printer, and allied Miniaturization equipment by K&E.

Name & title _____

Company & address _____



KEUFFEL & ESSER CO.

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1519

Write in No. 20 on Reader Service Card at start of Product Preview Section



HIGH PERFORMANCE 2-Inch Cooling Fan

AiResearch Minifan* is an extremely high performance 400-cycle AC motor-driven fan used for cooling airborne or ground electronic and electrical equipment. Model shown has a flow capacity of 53.5 cfm at a pressure rise of 3.44 H₂O, and requires only 69 watts.

Minifan operates up to 125°C. ambient. Its size and weight make it ideal for spot cooling, cold plates or as a cooling package component. The fan can also be repaired, greatly increasing its service life.

Range of Specifications

- Volume flow: 21.5 to 53.5 cfm
- Pressure rise: .6 to 3.44 H₂O
- Speed: 10,500 to 22,500 rpm
- Single, two or three phase power
- Power: 16 to 69 watts
- Standard or high slip motors
- Weight: .36 to .48 lb.

A world leader in the design and manufacture of heat exchangers, fans and controls, AiResearch can assume complete cooling system responsibility. Your inquiries are invited.

*Minifan is an AiResearch trademark.

THE GARRETT CORPORATION
AiResearch Manufacturing Division
Los Angeles 45, California

Write in No. 21 on Reader Service Card
April 1960

PRODUCT PREVIEW

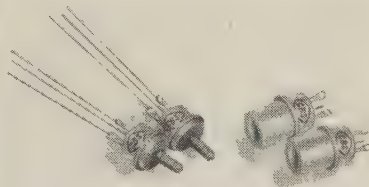
TV CAMERA has good resolution

More than 600-line resolution is obtained in this closed-circuit TV camera, which has an eight-mc bandwidth, says Packard Bell Electronics Corp., Dept. S/A, 12333 W. Olympic Blvd., Los Angeles 64, Calif. The unit is designed with a single operating control, fully regulated power supply, keyed automatic black level control, and automatic light compensator.

Video output is 1.4 V peak to peak composite signal with 30 per cent sync, frame frequency is 30 per sec, and vertical and horizontal sweep frequencies are 60 and 15,750 cps, respectively. Available remote accessories include auto-zoom lens, control turrets, and weather-proof housing with windshield wiper.

Write in No. 203 on Reader Service Card

POWER TRANSISTORS are complementary



This first line of complementary NPN-PNP power transistors in industrial packages are available for complementary circuits. These eight pairs of industrial transistors offer economy, miniaturization, and improved frequency response, says CBS Electronics Information Services, Dept. S/A, 100 Endicott St., Danvers, Mass.

All types have a maximum collector current of 30 amp, a minimum large-signal current gain of 30, (for a collector current of 0.5 amp) and a maximum thermal resistance of 3 deg C/W.

Write in No. 204 on Reader Service Card

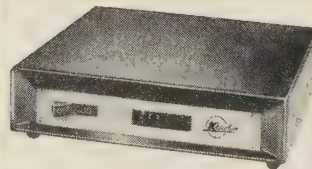
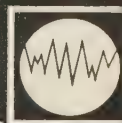
POWER ISOLATOR has feedback circuit

This power isolator provides an output isolated from line voltage and line ground. Isolation is obtained through the use of a feedback isolation circuit and a specially shielded transformer. Unit provides up to 300 va of isolated power at 115 vac 60 cycles, says Moeller Instrument Co., Electronics Div., Dept. S/A, 132nd St., & 89th Ave., Richmond Hill 18, N. Y. Line-operated devices can be supplied with ideal isolation, eliminating necessity of common ground.

The unit was designed for use with oscilloscopes, voltmeters, amplifiers, signal generators, power supplies, recorders and other items.

Write in No. 205 on Reader Service Card
more on page 250

BASIC BUILDING BLOCKS FROM KEARFOTT



PRECISE ANGLE INDICATOR

Consisting of an angle position indicator, motor and servo amplifier, this small, versatile, rack panel mounted unit provides angular position indications for laboratory, production and field use. Input signals proportional to unknown angular position of synchro device being measured are resolved as an error voltage, which is amplified and used to drive an internal servo loop to null. Counter mechanism then provides direct visual readout of angular position.

TYPICAL CHARACTERISTICS

Input Signal: S₁, S₂, and S₃ of external synchro transmitter.

Repeatability: Within 0.6 minute in either a clockwise or counterclockwise direction for any angular position.

Readability: 0.5 minute through full range from zero to 360°
Rotation is continuous.

Accuracy: ± 6 minutes in the standard unit. Other accuracies available on request.

Sensitivity: 0.5 minutes maximum.
Slewing Speed: Phase sensitive, 180° in 7 seconds.

Input Voltages: 115 volts, single phase, 400 cycles, 23 VA max.

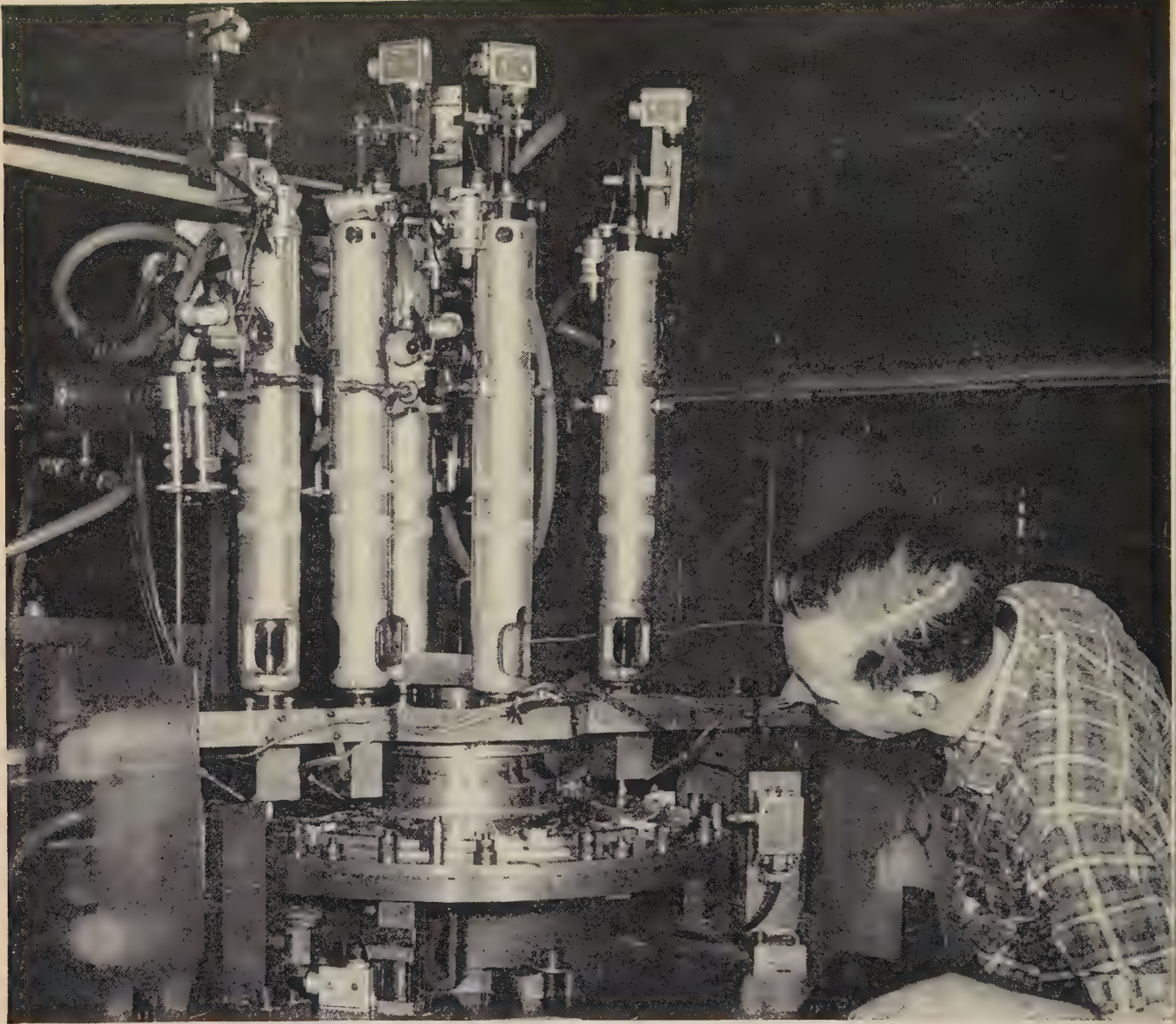
Size: Standard Rack Mounting—1 3/4" x 9 1/2" x 8 1/2"

Write for complete data.



KEARFOTT DIVISION
GENERAL PRECISION INC.
LITTLE FALLS, NEW JERSEY

Write in No. 22 on Reader Service Card



"Airfeeddrills"® cut drilling time 88% on jet aircraft part

Time required for drilling 104 holes in a bearing support for a jet aircraft compressor was cut 88% when the manufacturer switched from other methods to five Gardner-Denver "Airfeeddrills."

Three bolt circles were drilled at two different levels; 72, 8 and 24 holes were drilled in bolt circles 18 $\frac{7}{8}$ ", 10.2" and 8.5" respectively. All holes in the material—AMS-6415—were drilled to close Air Force tolerances. A 36-station index table, plus automatic "Airfeedrill" controls, automated the entire operation.

VERSATILITY AND INTERCHANGEABILITY

This is just one more example of the versatility and

interchangeability of Gardner-Denver "Airfeeddrills." They're easily adapted to almost any drilling setup. You mount them as a drilling unit of 2, 20 or more spindles for automatic hole processing. Use one as a stationary drill mounted on an inexpensive fixture. As a portable drill, "Airfeedrill" hangs by its nose to a jig for precision drilling.

See for yourself how quickly and inexpensively you can automate *your* drilling operations . . . see your Gardner-Denver representative or write for Bulletin 92-1 on "Airfeedrill" specifications and applications.



EQUIPMENT TODAY FOR THE CHALLENGE OF TOMORROW

GARDNER - DENVER

Gardner-Denver Company, Quincy, Illinois

In Canada: Gardner-Denver Company (Canada), Ltd., 14 Curity Ave., Toronto 16, Ontario

Write in No. 23 on Reader Service Card at start of Product Preview Section

SPACE/AERONAUTICS

WANT TO BE MORE POSITIVE ABOUT CHIPS?

TEDECO SELF CLOSING ELECTRIC CHIP DETECTOR PLUGS are an ever watchful guard over bearings and gears, giving warning of any deterioration. They incorporate a new patented magnet and electric contact arrangement that draws chips into the circuit gap and assures bridging of the contacts as chips accumulate. Since any electric chip detector can only indicate impending breakdown—the extent must be appraised by visual inspection.

Tedeco Self Closing Electric Chip Detector Plugs provide for easy inspection of the chips without fluid drainage or spillage. For more positive chip retention—for easy positive appraisal of chip accumulation specify Tedeco Self Closing Electric Chip Detector Plugs.



**TEDECO
SELF CLOSING
ELECTRIC
CHIP
DETECTOR
PLUGS**

FOR MORE
POSITIVE CHIP
RETENTION
PLUS EASY
VISUAL
INSPECTION



**TEDECO
BAYONET TYPE
SELF CLOSING
MAGNETIC
DRAIN
PLUGS**

FOR POSITIVE
ROUTINE
VISUAL
INSPECTION
No Tools—No Wires
*Just a twist of
the wrist...*

SEND FOR CATALOG 3-60—TEDECO
AVIATION GRADE
GEAR CASE
ACCESSORIES

TEDECO

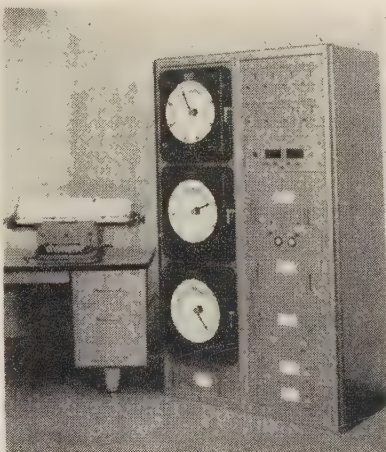
**TECHNICAL DEVELOPMENT
COMPANY**

GLENOLDEN, PA. LUDLOW 3-3330

Write in No. 24 on Reader Service Card
April 1960

PRODUCT PREVIEW

RECORDING SYSTEM for temperature data



This temperature data recording system is designed to measure and record up to 75 iron constant thermocouple inputs. It can be used in engine test work, process monitoring, and applications where periodic, accurate recording of temperatures is desired, says Datex Corp., Dept. S/A, 1307 So. Myrtle Ave., Monrovia, Calif.

Three temperature ranges are provided: —30 to 120 deg F; 250 to 600 deg F; and 0 to 1200 deg F. Scanning rate is 3 seconds per data point; the scan cycle duration is 225 seconds.

Write in No. 206 on Reader Service Card

DATA AMPLIFIER in miniature design



A transistorized data amplifier that amplifies mv-level ac instrumentation signals and can be used over a —55 to ± 100 -deg C range measures $\frac{7}{8} \times \frac{7}{8} \times 1\frac{1}{2}$ in., according to The Mira Corp., Dept. S/A, 2656 N. Pasadena Ave., Los Angeles 31, Calif. The hermetically-sealed, 1.5-oz device, suitable for airborne use, has an input impedance of over five meg at 400 cps, independent of input amplitude, and an output impedance of under 10 K.

Voltage gain is 20 plus or minus one per cent, and frequency response is ten cps to 100 kc, plus or minus one db.

Write in No. 207 on Reader Service Card
more on page 255

BASIC BUILDING BLOCKS FROM KEARFOTT



FLOATED RATE INTEGRATING GYROS

Specifically designed for missile applications, these Kearfott miniature gyros operate efficiently at unlimited altitudes. Their outstanding accuracy and performance make them superior to any comparably-sized units on the market. Hermetically sealed within a thermal jacket, these gyros are ruggedly designed and completely adaptable to production methods. Performance characteristics that are even more precise can be provided within the same dimensions.

TYPICAL CHARACTERISTICS

Mass Unbalance:

Along Input Axis: 1.0° / hr
maximum untrimmed

Standard Deviation (short term):

Azimuth Position: 0.05° / hr

Vertical Position: 0.03° / hr

Drift Rate Due to Anisoelectricity

Steady Acceleration:

$.015^\circ$ / hr. / g^2 maximum

Vibratory Acceleration:

$.008^\circ$ / hr. / g^2 maximum

Damping:

Ratio of input angle to
output angle is 0.2

Characteristic Time:

.0035 seconds or less

Weight: 0.7 lbs.

Warm-Up Time:

10 minutes from -60° F

Life: 1000 hours minimum

Write for complete data.



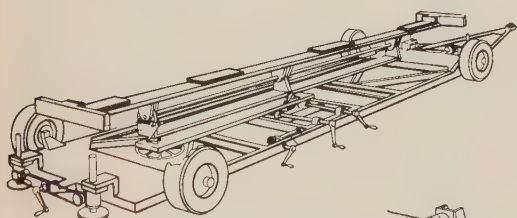
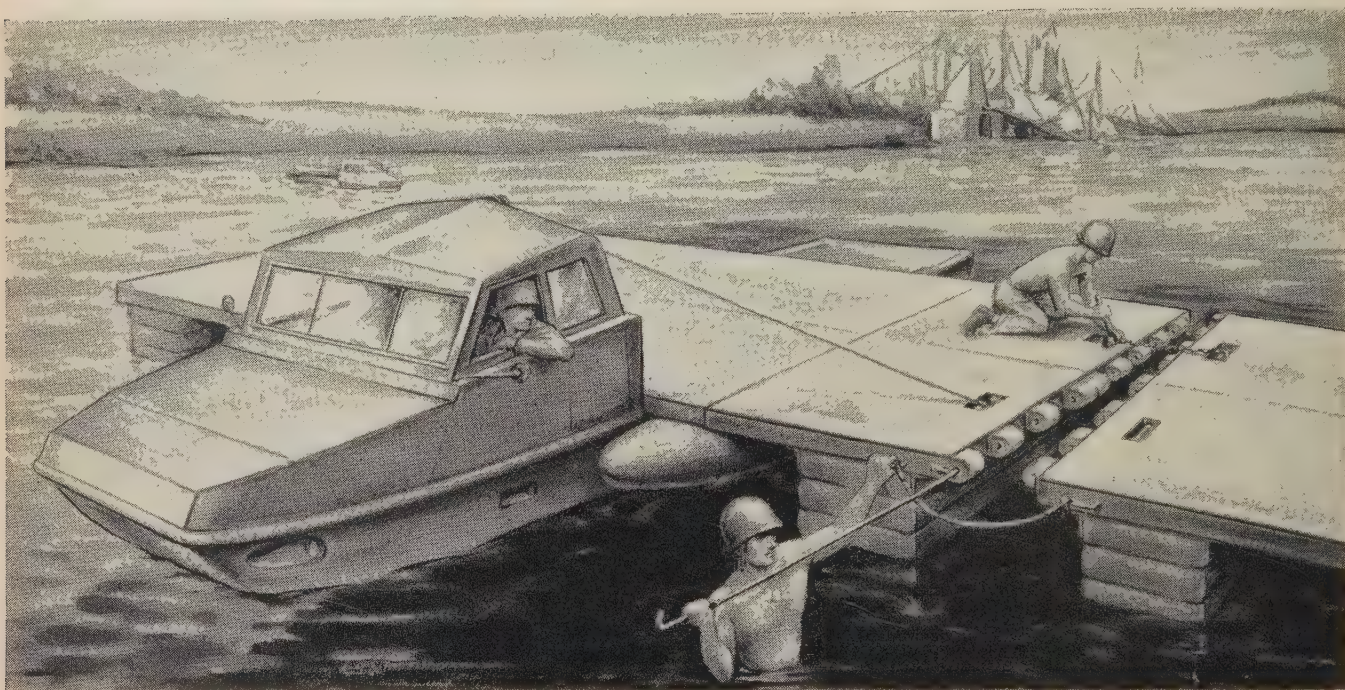
KEARFOTT DIVISION

GENERAL PRECISION INC.

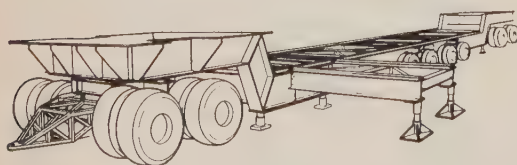
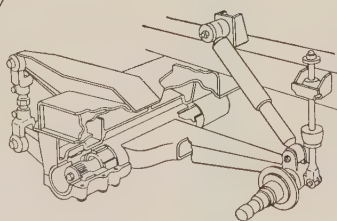
LITTLE FALLS, NEW JERSEY

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CREATIVE VERSATILITY FOR THE AGE OF SPACE



**FRUEHAUF
PRODUCES
RESULTS!**



Fruehauf has the creative talent and facilities to handle your mobile housing, handling, launching or maintenance prime or sub-contracts

With the dawn of the space age came many varied and complex problems not directly related to the actual launching of rockets and missiles. Among these problems was that of designing and building ground-handling equipment and facilities ranging from new concepts in bridging to nuclear reactor transporters. One of the organizations best prepared to cope with these unique problems is the Fruehauf Trailer Company.

At your command are Fruehauf's nationwide facilities—research, engineering, development and production—staffed with highly trained military specialists with the capability to carry your ground handling problems from concept to completion.

Whatever your military ground handling problems may be, it will pay you to consult Fruehauf—America's most trusted and experienced designers and developers of precision-produced equipment for the age of space!

Plants in the East and West

MILITARY EQUIPMENT DIVISION — DETROIT 32, MICH.

MISSILE PRODUCTS DIVISION — LOS ANGELES 58, CALIF.



Write in No. 26 on Reader Service Card at start of Product Preview Section

SPACE/AERONAUTICS



KEARFOTT developed
and now produces
the Bomarc-B all-attitude
mid-course
guidance system.

*Engineers: Kearfott offers challenging
opportunities in advanced component and
system development.*



KEARFOTT DIVISION

LITTLE FALLS, NEW JERSEY



GENERAL PRECISION, INC.

OTHER DIVISIONS OF GENERAL PRECISION INC. — GPL-LIBRASCOPE-LINK

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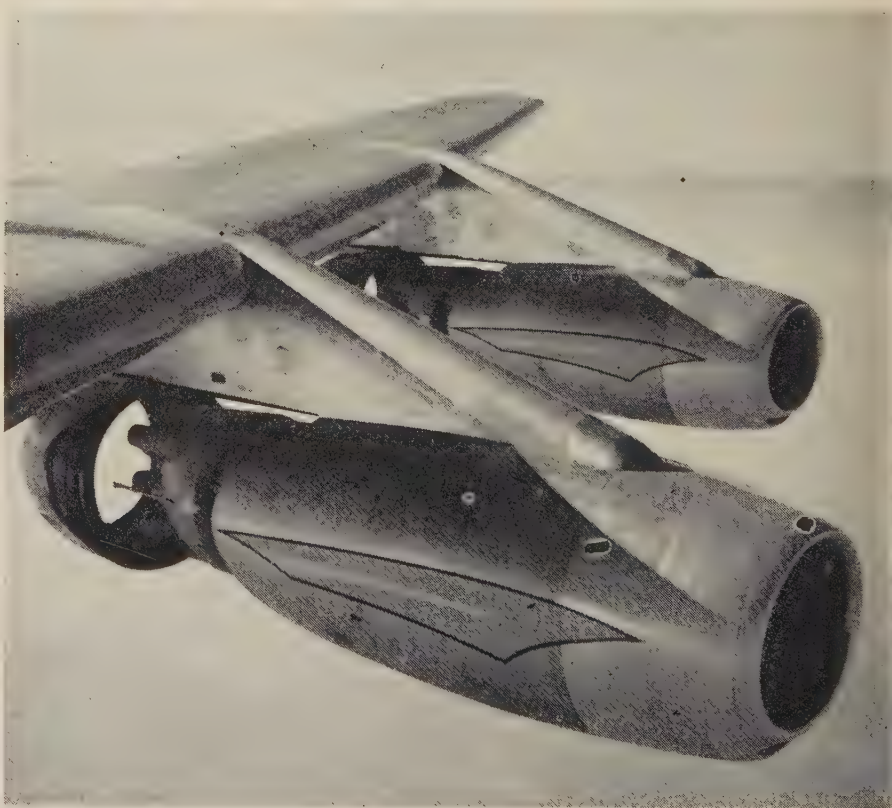


Armco 17-7 PH Stainless Specified in the DC-8 To Help Assure Best Possible Performance

As a result of Douglas Aircraft Corporation's continuous development program to insure best performance for their commercial aircraft, Armco 17-7 PH Stainless Steel has been specified for critical parts of the DC-8 engine-pylon units.

The high strength-weight ratio, corrosion resistance, and good elevated temperature properties of 17-7 PH are being utilized in the inner structure of the thrust ejector, the inlet cowl structure, and structural elements of the pylons.

Armco 17-7 PH and Armco's other precipitation-hardening stainless steels, 17-4 PH and PH 15-7 Mo, are providing designers of military aircraft and missiles, as well as commercial airliners, with metals developed to meet their needs. Where you require ultra-high strength at temperatures up to 1000 F, combined with good corrosion resistance and proved producibility, take advantage of these Armco aeronautical stainless steels. For design data and complete information, write Armco Steel Corporation, 1540 Curtis Street, Middletown, Ohio.



New steels are
born at
Armco

ARMCO STEEL



Armco Division • Sheffield Division • The National Supply Company • Armco Drainage & Metal Products, Inc. • The Armco International Corporation • Union Wire Rope Corporation

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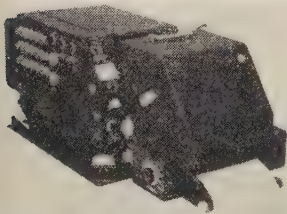
**TOGGLE SWITCH
pulls to unlock**

This precision pull-to-unlock toggle switch, designated "13AT," has a positive lever locking device as an integral part. It holds the toggle lever in a set position, preventing accidental toggle lever movement. Contact arrangement of each of the sub-miniature basic switches in an assembly is single-pole double-throw, according to Minneapolis-Honeywell Regulator Co., Micro Switch Div., Dept. S/A, Freeport, Ill. They may be used normally open or normally closed.

It is available in many combinations from 2-pole through 4-pole units, with or without gold contacts and/or turret type terminals.

Write in No. 208 on Reader Service Card

**OSCILLOGRAPH MAGAZINE
provides rapid access**



The Datarite, termed type 5-047, allows a "quick look" at data from tests while in progress. The magazine is interchanged with the standard magazine used on their type 5-114 Recording Oscillograph, says Consolidated Electrodynamics Corp., Electro Mechanical Instrument Div., Dept. S/A, 360 Sierra Madre Villa, Pasadena, Calif.

Fully developed, dry oscillograms are provided by the magazine in as little as 0.8 sec after exposure. All processing is done inside the magazine from a single-solution developer.

Write in No. 209 on Reader Service Card

**GROUNDSPEED INDICATOR
for helicopters**

Model AN/APN-97 is a CW Doppler navigation set designed primarily as a ground velocity indicator for helicopters. The set automatically and continuously measures and displays heading speed, drift speed and vertical speed in aircraft reference coordinates with aid of ground stations, wind estimates or true airspeed data, says Ryan Aeronautical Co., Dept. S/A, San Diego, Calif.

The equipment is designed for low altitude hovering and navigation. A hovering sensitivity of 1/2 knot permits holding a very tight hover, either manually or automatically. Navigational accuracy, a function of altitude, permits errors of less than 4 per cent over land at altitudes below 1000 ft.

Write in No. 210 on Reader Service Card

more on page 257



Environmental testing of TARMAC ASR-4 Airport Surveillance Radar System, developed and produced for the Federal Aviation Agency.

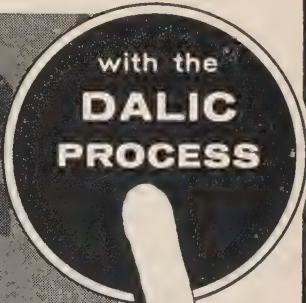
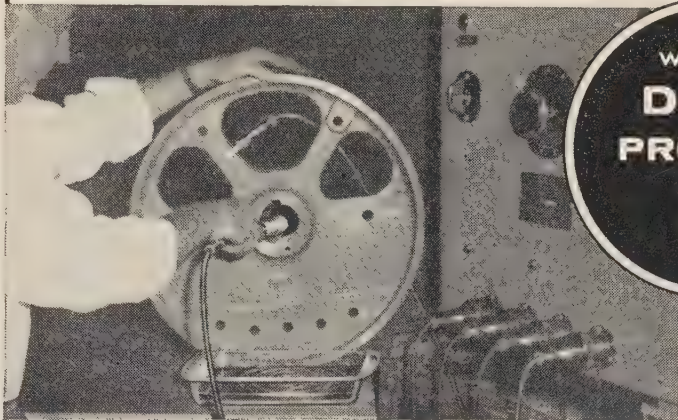
**TI IN HEAVY RADAR
SYSTEMS**



**TEXAS INSTRUMENTS
INCORPORATED**
6000 LEMMON AVENUE • DALLAS 9, TEXAS

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SELECTIVE PLATING



**Production and Repair Plating
without using immersion tanks**

Enables You to (1) Precision-plate selected areas economically — without disassembling components; (2) Deposit metals rapidly where conventional electro-plating is impossible or difficult. Mobile equipment takes the process to the job.

Write for Descriptive Brochure.

SIFCO METACHEMICAL, INC.

935 East 63 Street • Cleveland 3, Ohio

A Subsidiary of The Steel Improvement & Forge Co.

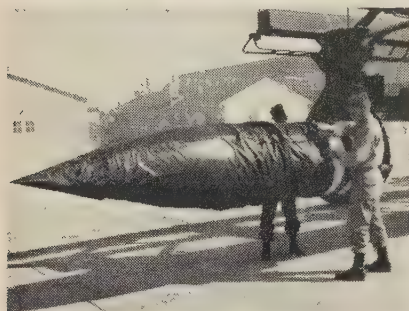
AGENTS

MARLANE DEVELOPMENT CO., INC. PIDDINGTON & ASSOCIATES LTD. OHIO METACHEMICAL, INC. D & S AVIATION CO., LTD.
153 East 26th Street 3219 East Foothill Blvd. 2742 Second Street 671 Laurentides Blvd
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Write in No. 30 on Reader Service Card at start of Product Preview Section

3M Materials Memo

News of material for the aerospace industry—from the 27,000 products of the 3M Company



■ GOT A DIRTY BIRD?

You needn't have. Missile "raincoats" made from 3M's new 4222 coated fabric protect against not only the ravages of the weather, but the attack of solvents and fuels, as well. This new polyester coating, available on nylon, Dacron, glass cloth, or other types of fabrics, is by no means a fair weather friend. It takes the punishment of wind and salt spray, has abrasion resistance greater than all other commonly used coatings, and offers excellent resistance to mildew. It's no slouch either when skies are blue. It has superior sunlight and ozone resistance. At temperatures as low as -80°F, it retains its flexibility and it's still in there pitching at 375°F. What's more, this low temperature flexibility is permanent. There are no plasticizers to bleed out upon aging.

The fuel and solvent resistance of this versatile fabric is a story in itself. It's quite at home with aromatics, aliphatics, ketones, and esters, as well as jet fuels, synthetic ester oils and hydraulic fluids. These characteristics have literally revolutionized the thinking in storage of fuels. For example, by today's standards, do you know the difference between a fuel tank and a hole in the ground? The answer is 4222 fabric of course! Spread out as a fuel resistant layer over the surface of an excavation, the hole becomes a cheap, safe storage well for jet fuels, diesel fuels, or oils. The finishing touch is another layer of 4222 to provide a cover.

Armed with these remarkable properties and your imagination, even the sky's no limit for you and 4222. For more information, either check below or see your ELECTRICAL PRODUCTS representative.

■ A BRIGHT IDEA!

Ever think of getting your illumination by the gallon? As farfetched as it may seem—such a thing is possible now, thanks to 3M's "CODIT" reflective liquid. Night handling and launch operations need no longer hold any qualms for you, if you take advantage of "CODIT's" unique retro-reflective properties.

"CODIT" has been "showing up" on the electrical connectors in many of today's

missile systems. A quick glance with a portable light shows you in an instant whether these vital connections have been properly made. Even the security people are praising the virtues of "CODIT" in its ability to quickly show whether enclosures are open or closed, fences have been cut, or a piece of equipment has been moved or taken from a storage area.

"CODIT's" suspension of special reflective elements in a solvent dispersed vehicle returns light directly back to its source about 60 times as bright as any white paint could. Furthermore, it reflects at all angles, too. You still get reflectance when your viewing angle is almost 90° with respect to the normal of the coated surface. This is particularly important on rounded or complex shapes.

"CODIT" can be applied by spraying, brushing, hand rolling, or silk screen printing to most clean, dry surfaces. It even takes concrete, rough metal, and wood in its stride. Having a durability comparable to a high grade of exterior enamel, it can be used for exterior applications provided the surface is weatherproof or suitably treated. There is more information to be had from your REFLECTIVE PRODUCTS representative or clip the coupon below.

■ THE HOLE STORY

Want to know what's in a missile? Chances are you can find out from a "Filmsort" Aperture Card, a product of THE FILMSORT COMPANY, one of the divisions of 3M. The engineering drawings for the components of a missile go into these "Filmsort" Aperture Cards. It's no trick to put an engineering drawing as big as 34 x 44" into a standard punch card. All you do is microfilm the 34 x 44" drawing first. The "Filmsort" Aperture Card is simply the winning combination of microfilm and punch cards.



What does The Filmsort Company do? It produces the aperture cards that make microfilm standard, simple and practical.



Several agencies and their prime contractors for missile systems use these "Filmsort" Aperture Cards to keep up with the pace of the space age. These cards have something to do with time—not the time in space, but the time in our everyday world. Seems that in less than 90 seconds, you can put your hands on any one of these cards out of thousands in a file. Then simply take the "Filmsort" Aperture Card to the Thermo-Fax "Filmac 200" Reader-Printer. Now, you can take a look... or take more than a look, take a copy. That's all it takes to get a print these days.

If you'd like to learn more about these "Filmsort" Aperture Cards and expect to be in New York April 19-21, see a demonstration at the National Microfilm Convention in the Statler-Hilton Hotel. If you're chained to the desk then The Filmsort Company will be glad to send you the hole story if you'll so indicate below.

■ ABOUT "MIL"

3M's Missile Industry Liaison is a service staffed by technical personnel experienced in rocket propulsion and other phases of space technology. Their job is to translate problems of the aerospace industry to those 3M specialists best qualified to solve them. If you have questions on any of the items mentioned here, or would like to know what else 3M makes—or could make—for your needs, mail coupon.

3M Company, Missile Industry Liaison — VAA-40
St. Paul 6, Minn.

Please send more information on ☐ 4222 Coated Fabric
☐ 3M "CODIT" Reflective Liquid ☐ "Filmsort" Aperture Cards

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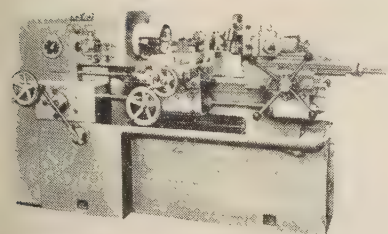
... WHERE RESEARCH IS THE KEY TO TOMORROW



MISSILE
INDUSTRY
LIAISON

Write in No. 31 on Reader Service Card at start of Product Preview Section

TURRET LATHE has medium capacity



The Heinemann RS 40 turret lathe can handle many turning jobs now performed on more expensive, heavier machines, says Production Equipment Co., Dept. S/A, 307 S. Chester Pike, Glenolden, Pa.

Bar capacity is 1½ in. and swing is 14½ in. The machine features infinitely variable spindle speeds on two overlapping ranges: 65 to 470 rpm; and 400 to 2700 rpm. Other features are a six-station, self-indexing turret with eight longitudinal feeds, a square turret on the cross slide with eight reversible turning and facing feeds, micrometer dial reading for turret feed, instant high-low gear shift, coolant tank, chip strainer, and other devices. All feeds are power operated.

Write in No. 211 on Reader Service Card

CATHODE RAY TUBE for microwave frequencies



Called the Wamoscope, this compact cathode ray tube is capable of presenting microwave frequency information directly on its screen. The tube which was developed for use in advanced electronic systems applications, does not require a solenoid, says Sylvania Electric Products Inc., Dept. S/A, 730 Third Avenue, New York 17, N.Y.

The Wamoscope is only slightly longer than conventional television picture tubes and operates over a frequency range of from 2 to 10 kmc. The tube will be particularly important in high-resolution radar applications. The new tube has a signal coupler incorporated within the tube envelope and spot size has been improved to 160 lines per inch at the center of its 10 in screen.

Write in No. 212 on Reader Service Card
more on page 259



Navy's CORVUS Air-to-Surface Missile Designed and Produced by TEMCO

TI TELEMETRY IN MISSILE SYSTEMS



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for all your

CLIP, BLOCK and HARNESS STRAP needs!

ADEL offers the widest variety of LINE SUPPORTS in the World . . . 19,000 different types and sizes for safe, vibration-free, positive support in all types of aircraft, missiles, rockets, ordnance, automotive and original equipment of all kinds.

SAFETY . . . FLEXIBILITY . . . DURABILITY . . .
ECONOMY . . . SERVICE FITTED . . . SERVICE
TESTED . . . SERVICE APPROVED

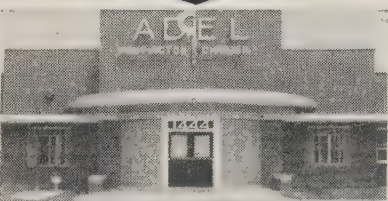
Illustrated are but a few of the World's most complete line of Line Supports that meet or exceed all applicable specifications and/or requirements. Whatever the application—STANDARDIZE ON ADEL—the leader in completeness of line, service and reliability.

Reliability

ADEL PRECISION
PRODUCTS
A DIVISION OF GENERAL METALS CORPORATION

SPECIFICATIONS ARE AVAILABLE TO AIRCRAFT,
MISSILE AND ORIGINAL EQUIPMENT MANUFACTURERS . . . WHAT ARE YOUR REQUIREMENTS?

Direct inquiries to Huntington Division
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Dayton • Wichita • Dallas • Toronto



Write in No. 33 on Reader Service Card at start of Product Preview Section

move it in . . . couple it . . . turn it on . . .

with a **VICKERS**® "packaged" unit
power is instantly available to operate
your missile-support system

Fast and easy installation is an important advantage of these "packaged" hydraulic power and control systems by Vickers. It saves time at the missile site — keeps "on-the-spot" labor charges low. That's important! Yet this fast installation is only one of the benefits you get with these factory-built power packages.

Save Design Time — Since 1932 Vickers has custom designed hydraulic power packages. Thus, we know how to avoid "false starts" and can develop highly efficient units *in a hurry*.

Eliminate Mismatching — Each power package contains compatible, balanced components all produced by Vickers. There are no hybrids — there is no need for "force fits".

Save Space — Units are surprisingly compact, yet all components are easily accessible. Solid steel drilled manifolds reduce piping and space. Components, lines and connections are kept to an absolute minimum.

Simple Field Adjustment — The building-block concept is followed to

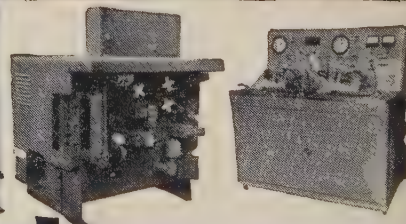
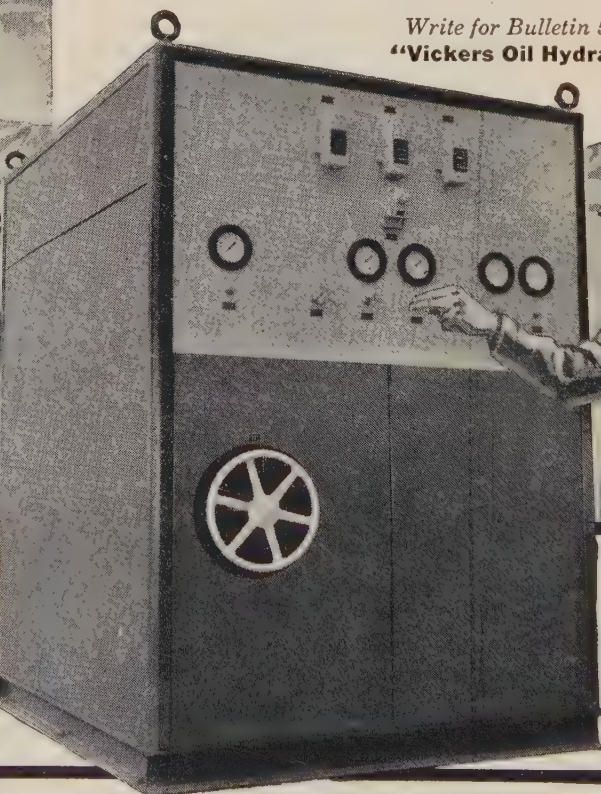
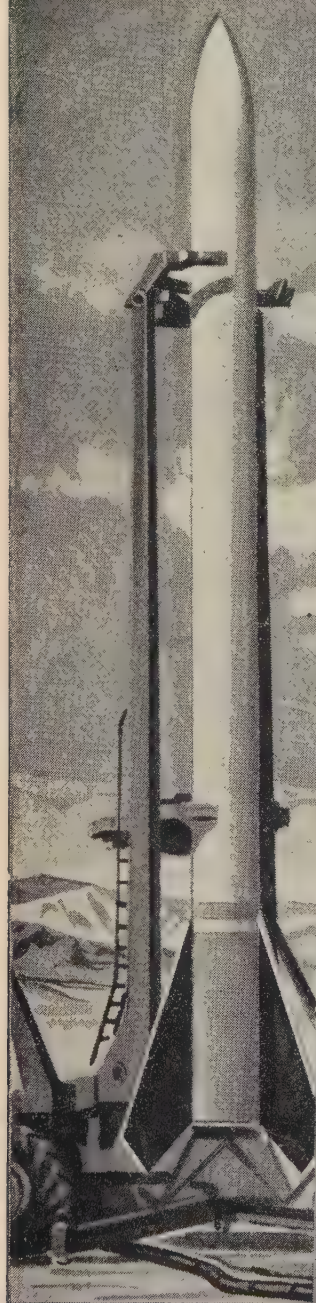
give component interchangeability, servicing ease and quick location of any malfunction. All components are individually tested; complete power units are pretested before shipment.

Insure Predictability — Vickers designs and builds systems which meet the most rigid performance specifications including predicted ambient temperature, weather and other conditions.

Reduce Field Inventory — As far as possible, units are designed with components that are commercial "shelf" items. Inventories of warehouse stocks can be kept low because of component and part interchangeability.

How far advanced is your project? If it is in the design and development stage, we can *immediately* place a team of hydraulic specialists in your plant to work with your engineers. If it is in the "breadboard" stage, let us give you an alternate proposal. On many applications we have suggested much improved power units at attractive production-line prices.

Write for Bulletin 5303
"Vickers Oil Hydraulics for Missile Systems"



VICKERS INCORPORATED
DIVISION OF SPERRY RAND CORPORATION
Marine and Ordnance Department
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Hydraulic Products
for Marine
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SPACE/AERONAUTICS

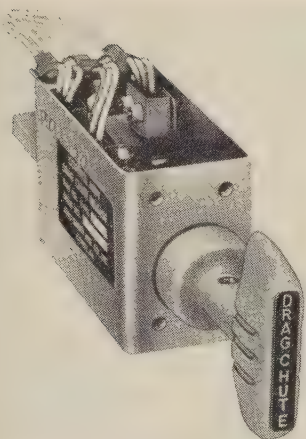
CIRCUIT BOARDS give high tolerances

A special etching process now maintains tolerances of ± 0.0005 and clarity of printed circuitry according to Spec-Tronics, Dept. S/A, 13942 Saticoy St., Van Nuys Calif.

Plated-through-hole boards—either gold-plated, flash gold, tin plate and solder coat plating—together with nickel rhodium tips are available under this process.

Write in No. 213 on Reader Service Card

CHUTE RELEASE weighs 0.8 pound



This compact, light weight drag chute release, No. 11-2161-000, has an electromechanical control that provides a deliberate action where programed switching is the requirement. It weighs .8 lb. It is qualified for 10,000 cycles of endurance, says Aero Supply Mfg. Co., Inc., Dept. S/A, Corry, Pa. In its initial application the control functions in two operations, the first permitting a chute to be released, the second disengaging the chute from the aircraft.

It may be designed to other specific aircraft requirements.

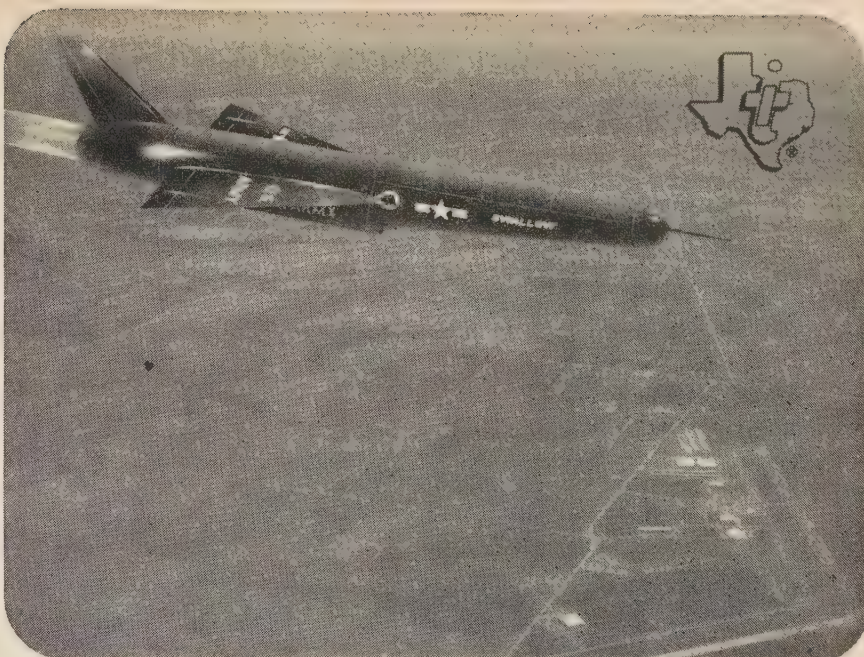
Write in No. 214 on Reader Service Card

SELECTOR SWITCH for "cock-and-fire"

This series of rotary selector switch assemblies features a "cock-and-fire" actuating mechanism and non-tease circuitry. The 28AS series are designed for use on aircraft, electronic and computer panels, and other areas where mounting surface is at a premium, says Minneapolis-Honeywell Regulator Co., Micro Switch Div., Dept. S/A, Freeport, Ill. They can be provided with two to eight plastic-enclosed single-pole/double-throw basic switches and two or three actuator positions.

The levers are operated by precision cams which are rigidly mounted on the actuator shaft in the desired operation sequence.

Write in No. 215 on Reader Service Card
more on page 261



U. S. Army Signal Corps SWALLOW AN/USD-4 Combat Reconnaissance Drone
Produced by Republic Aviation—Equipped with TI Surveillance Sensors

TI IN SURVEILLANCE SYSTEMS

APPARATUS
DIVISION

TEXAS INSTRUMENTS
INCORPORATED

6000 LEMMON AVENUE • DALLAS 9, TEXAS

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Electro
ELECTRONIC EQUIPMENT

**MAGNETIC
TRANSDUCERS**

SUB-MINIATURE 3055

Actuates,
Provides Tele-
metering Data,
Indicates,
Controls,
Synchronizes.

← ACTUAL SIZE

A precise way to solve your speed measurement problems

Here's how to measure turbine speeds up to 100,000 rpm...

- a. Mount Magnetic Pickup near teeth of any convenient gear in the machine—or add a small bit of magnetic material to a non-magnetic rotor.
- b. Connect Magnetic Pickup directly to electronic counter. Set counter to count for a suitable time—such as 1 second (1/60 minute).

Example: 60-tooth gear providing 60 pulses/revolution with a count of 1 sec. (1/60 min.) will produce an accuracy of ± 1 rpm at any speed. (Counter reads rpm directly with this set-up.) If counting time is increased to 10 sec., accuracy will be $\pm 1/10$ rpm.

Write for Specification 58.084

ELECTRO PRODUCTS LABORATORIES 4501-C Ravenswood, Chicago 40

Canada: Atlas Instrument Corp., Ltd., Toronto, Ontario

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Amchem points the way...

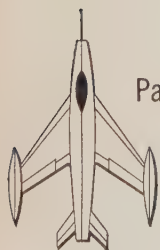
ALODINE 1200S

a new surface
conversion treatment
for aircraft
aluminum!



If you are producing aluminum for aircraft fabrication, investigate the production advantages of Alodine 1200S—the new conversion coating that provides constant, uniform quality as well as big savings in time, equipment and processing costs!

Through increased chemical activity Alodine 1200S slashes processing time up to 50 percent! A 1200 system can be installed on your production line quickly and conveniently . . . and bath is maintained chemically . . . no special equipment required to control contamination. In an Alodine 1200S system, products can be processed through dip in the same time cycle other conversion coatings require for continuous spray lines. One processor is now using Alodine 1200S in a 45- to 60-second treating cycle compared with a former process which took six minutes—and he's doing it with no increase or revision in existing processing facilities!



Passed with flying colors!

The first major aircraft manufacturer has successfully completed rigorous testing procedures on Alodine 1200S and reports complete satisfaction of its many advantages in aircraft processing of aluminum. Write for details today!

Protect your aircraft aluminum fabrications best, at less cost, in less time with Alodine 1200S—qualified under Government Specification MIL-C-5541.



ALODINE 1200S

Amchem and Alodine are registered trademarks of AMCHEM PRODUCTS, INC. (Formerly American Chemical Paint Co.)

AMBLER, PA. • Detroit, Mich. • St. Joseph, Mo. • Niles, Calif. • Windsor, Ont.

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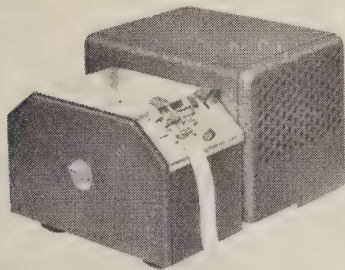
ISOLATORS for shock and vibration

These isomode shock and vibration isolators for use at temperatures up to 500° F. provide protection encountered in aircraft and missiles. Vibration sensitive airborne equipment such as radar antennae and electronic gear require effective isolation from high-frequency vibration, says MB Electronics, Dept. S/A, 20 Fitch St., New Haven 11, Conn. They consist of two load carrying springs mounted in opposed positions.

Diameters of springs, wire diameter, assembled length, number of turns of wire in springs, and helix angle of spring are so controlled as to provide spring rates in directions parallel to and perpendicular to the axis of the isolator.

Write in No. 216 on Reader Service Card

TAPE READER is miniaturized



Model 28 Miniaturized LXD punched-tape reader set is designed for a wide range of tape reading applications including on-line data transmission and off-line control of tape-operated factory of office machines, says Teletype Corp., Dept. S/A 4100 Fullerton, Chicago 39, Ill.

The unit features facilities for sequential output, hundred-word-per-minute transmission and reduced power requirements. The reader measures 5 $\frac{7}{8}$ x7 $\frac{1}{2}$ x9 $\frac{1}{2}$ in deep.

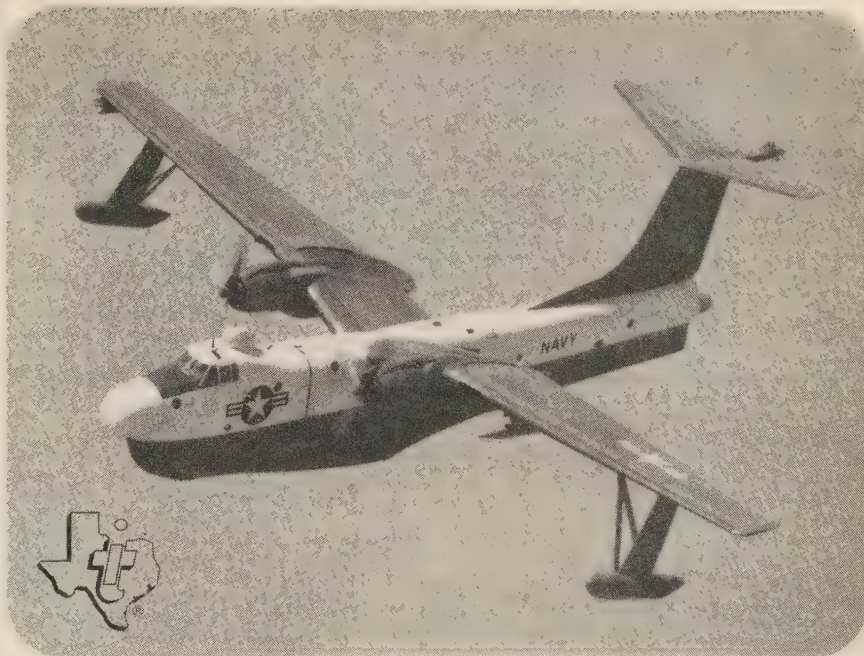
Write in No. 217 on Reader Service Card

PRESSURE SWITCH weighs 4 ounces

This pressure switch weighs 4 ounces and measures 3 in in length by 1 $\frac{1}{2}$ in at widest diameter. Ambient temperature range is -85 deg F to 300 deg F, but special versions can be provided for temperatures up to 600 deg F. The No. 1580 is factory set to actuate at a desired pressure level with the range of 0.5 psi up to 4,000 psi, says Haydon Switch, Inc., Dept S/A, Waterbury 20, Conn. All moving parts are in an aluminum housing environmentally sealed by O-rings at each end.

Unit is resistant to corrosive operating media, such as water-alcohol solutions, nitric acid and hydrogen peroxide.

Write in No. 218 on Reader Service Card
more on page 263



U. S. Navy P5M-2 antisubmarine patrol seaplane, produced by Martin—equipped with TI-built AN/APS-80 surface search radar, AN/APA-125A radar indicator, AN/ASQ-8 magnetic anomaly detector and TD-239A intervalometer.

TI RADAR & MAGNETICS IN ANTISUBMARINE SYSTEMS



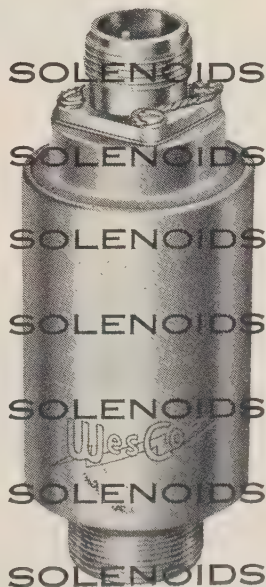
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6000 LEMMON AVENUE • DALLAS 9, TEXAS

Write in No. 38 on Reader Service Card at start of Product Preview Section



has hundreds of Aircraft and Industrial solenoids



Look to WesCo engineers with your aircraft or industrial solenoid problem. Hundreds of proven designs available. WesCo will modify or furnish special designs to fit your specifications.

Here are some of the features available:
High temp units tested past 600°F. • Adjustable plunger travel • Plunger cavity pressure sealed • Push or pull types 12 to 115 volts • Miniature, medium and heavy duty types • 400 cycle AC units also available.

Remember, when you need a solenoid, think of WesCo
AC INDUSTRIAL SOLENOIDS—full line. Write for brochure.
DC AIRCRAFT SOLENOIDS—send specifications, or write for catalog.

The trademark on
millions of solenoids since 1927



WEST COAST
ELECTRICAL MFG. CORP.
233 WEST 116TH PLACE • DIVISION 102
LOS ANGELES 61, CALIF. • PLYMOUTH 5-1138

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WRIGHT Quality

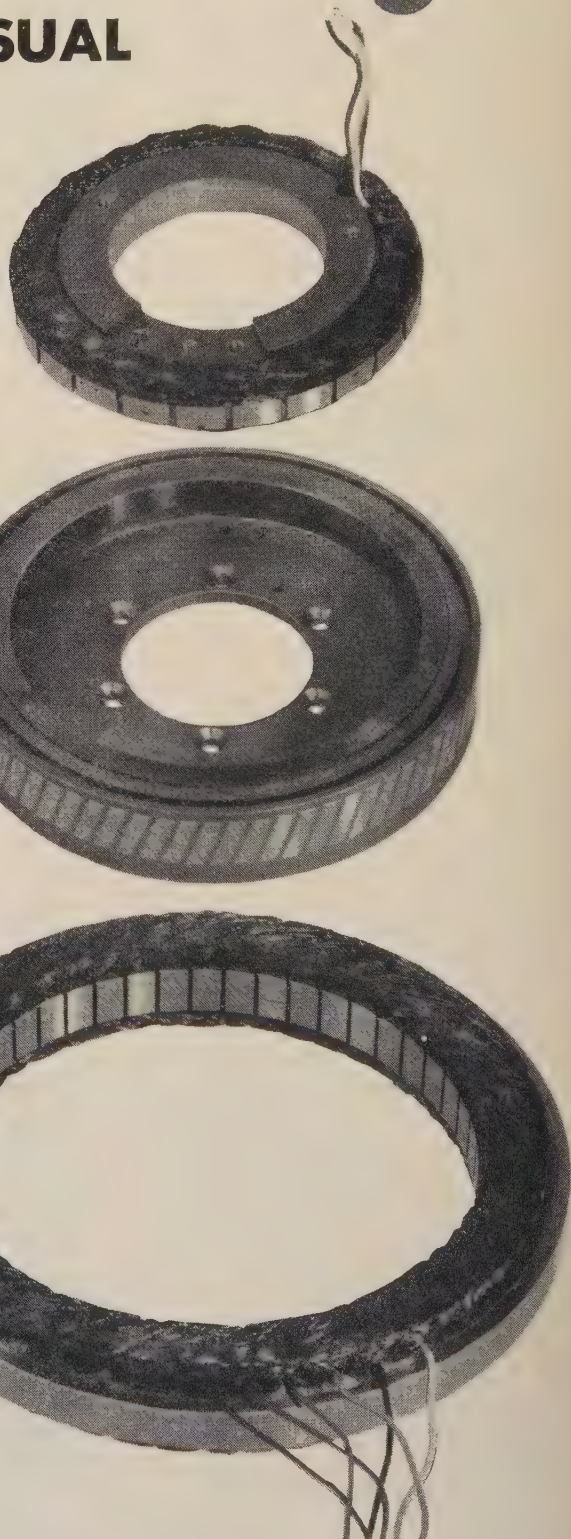
FOR REQUIREMENTS UNUSUAL

These stator and rotor combinations in flat design illustrate Wright Machinery's motor engineering and production capabilities. They are ideal components where the motor is built in and a conventional motor housing is not needed.

One class is the torquer, where the motor never attains running speed. They are made with 20 poles, generally two-phase 400 cycles; and are used, for example, to slave or precess a gyro. A skeleton type multi-pole slow speed servo may have real merit as compared with a high speed control motor with large ratio gearing. Currently, we are producing a two speed motor to operate at 600 and 300 rpm synchronous speeds on 60 cycles.

Another class is for gyro spin motors wherein the stationary wound element is inside, and the rotor is embodied in a fly wheel for high inertia. Wright "pancake" type units can also be supplied as synchros and resolvers.

If your precision motor requirements go beyond the catalog type, consult Sperry Rand's Wright Machinery division.



WRIGHT MACHINERY COMPANY

DIVISION OF SPERRY RAND CORPORATION
DURHAM, NORTH CAROLINA



SALES OFFICES in Durham, N. C.; New Hyde Park, Long Island, N. Y.; and El Segundo, Calif.

Write in No. 40 on Reader Service Card at start of Product Preview Section

SPACE/AERONAUTICS

This is the most
accurate, trouble-free
LEAK DETECTOR
you can buy



fast...simple...safe

• **Quick and Easy to Operate**

Flip a switch and the built-in automatic station does the work for you, electrically (no air supply required) ...lets you make up to 120 tests per hour...safety interlocks eliminate operator error, permits use of non-technical personnel.

• **Guaranteed Accurate and Safe**

Constant 10^{-10} cc/sec accuracy guaranteed by the patented VEECO VEETUBE®...it cleans itself...uses safe, inert helium as tracer gas.

• **Thoroughly Tested**

Each MS-9 undergoes a full week (168 hrs) of test run and inspection before shipment.

**MS-9 SERIES
PACKAGED
Helium
Mass Spectrometer
LEAK DETECTORS**

Finds leaks in
hermetically sealed
components

**WITH/WITHOUT
AUTOMATIC
ROUGHING STATION,
BACKFILL CONSOLE**



FREE MS-9 BROCHURE
contains full details on
performance, specifica-
tions, operation and
advantages. There is an
MS-9 series Leak Detec-
tor to fill your exact
need. Write Department
A-1435.

**Veeco VACUUM
CORP.**

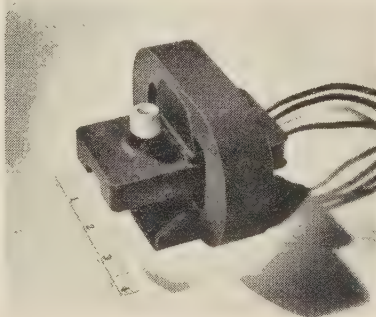
86 M Denton Avenue, New Hyde Park
Long Island, New York

HIGH VACUUM & LEAK DETECTION EQUIPMENT

Write in No. 41 on Reader Service Card
April 1960

PRODUCT PREVIEW

STOCK MAGNETRON
is voltage-tunable



A packaged voltage-tunable magnetron, the GL-7398 VTM, is now available from stock, according to General Electric Co., Dept. S/A, Schenectady 5, N.Y. It is basically a high-frequency oscillator with wide-spread applications in airborne and spaceborne receiving and transmitting equipment, such as countermeasures equipment, precision altimeters, telemetering, advanced radar, and proximity detection devices.

The device consists of a tube, radio frequency circuit or cavity, and a magnet, and the components are factory aligned and then locked together. It is voltage-tunable over part or all of a frequency spectrum from 2200 to 3850 mc, with a minimum CW power output of two W across the entire range. Features include a rapid tuning rate, high efficiency, small size, linear tuning, and flatter power output characteristics.

Write in No. 219 on Reader Service Card

COMPUTER
is fully transistorized

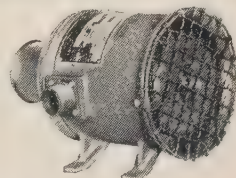


Model 1604 is a fully transistorized large-scale stored-program general-purpose digital computer. The computer is priced at a fraction of the price of any computer of comparable performance being offered in the U. S. today, says Control Data Corp., Dept. S/A, 501 Park Ave., Minneapolis 15, Minn.

A complete 1604 System can be installed in a room 20x20 ft. The main computer cabinet is only $7\frac{1}{2} \times 5\frac{1}{2} \times 2$ ft. It weighs 2200 lbs and consumes 4 Kw. The model 1607 magnetic tape system is of similar dimensions and power consumption.

Write in No. 220 on Reader Service Card
more on page 265

**JOY FANS
FOR
DOPPLER BAY
COOLING
KC-135**



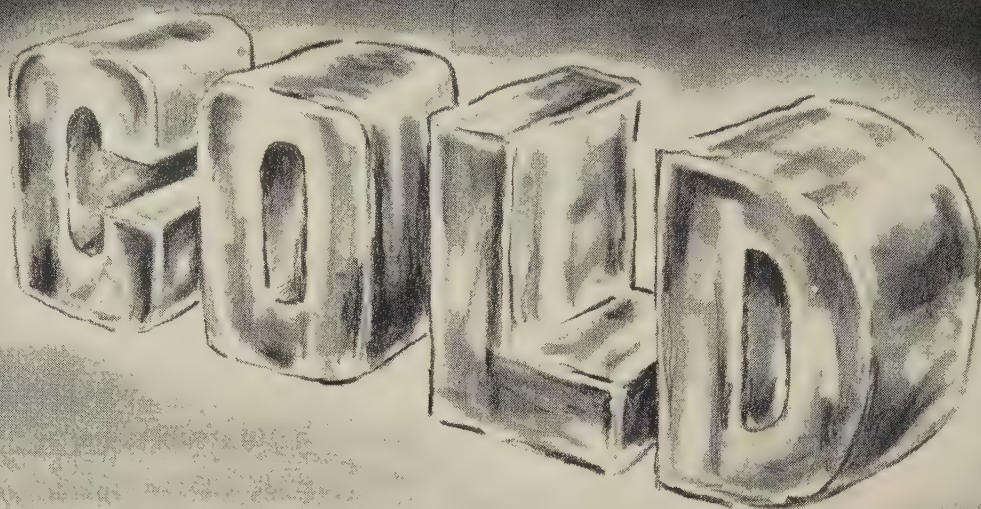
Fan No. X702-218A
Supplies 90 cfm
at 6.25" WGs
0.15 hp

JOY

Joy Manufacturing Company
Oliver Building • Pittsburgh 22, Pa.

Write in No. 42 on Reader Service Card

IT'S ALWAYS



SOMEWHERE...



And SAFEWAY Heating Blankets and Elements solve cold problems wherever they exist!

Maybe it's a basic defrosting problem in industrial refrigeration . . . or perhaps it involves the vital protection of aircraft from the icy upper atmospheres.

For these and scores of in-between applications, Safeway provides a *controlled heat* product, regardless of environmental temperatures. And people who know refrigeration depend on Safeway Heat Elements as a completely reliable and economical solution to defrosting problems in the commercial and industrial field.

Safeway's modern manufacturing facilities are devoted *exclusively* to the design, engineering and

application of *controlled heat* for industry. Among the wide variety of Safeway heating blankets, woven and molded heating elements are:

- heating elements for launching equipment and for airborne gyros, cameras, computers, servos and batteries — for missiles or aircraft
- de-icing units for airfoil surfaces
- heating elements for all types of ground support equipment
- defrosting units for industrial and commercial refrigeration
- heating blankets for honeycomb and metal-to-metal bonding

For your copy of a
fact-filled folder,
please write:

Safeway

HEAT
ELEMENTS
INC.

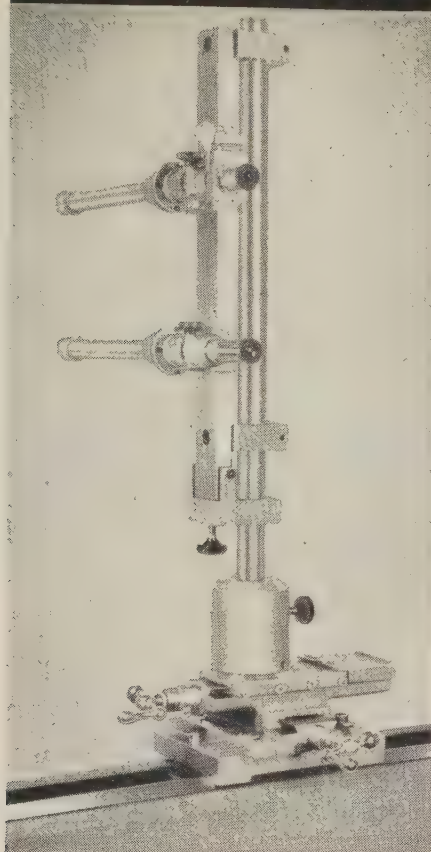
Middlefield Street • Middletown, Connecticut

If it has to be heated (and the "it" can be just about anything), you can rely on SAFEWAY engineers to study your problems carefully, and — without any obligation — submit an appropriate recommendation.

Write in No. 43 on Reader Service Card at start of Product Preview Section

SPACE/AERONAUTICS

INSTRUMENTS TO MEASURE LINEAR DIMENSIONAL CHANGES



Instrument shown measures specimens 2" to 12" long. Total range 0.040", reading to 0.0001". Has relay lenses for 8" working distance. Adjustment in 3 axes. Mounted on lathe bed type ways for use with multiple specimen setups. This instrument is representative of a line especially suited to measurements at high temperatures.

For help with your precision measuring problems, call on Gaertner experience

Your measuring problems may very well be nicely solved with optical instrumentation. Gaertner Scientific Corporation can probably recommend a standard or modified instrument to meet your particular needs. If necessary, we are fully equipped to design and build special instrumentation.

Gaertner has designed and built precision, scientific, optical and measuring instruments for over 60 years. Write or phone, and put this experience to work for you.

1270 Wrightwood Ave., Chicago 14, Ill. • BU 1-5335

Gaertner
SCIENTIFIC CORPORATION

Write in No. 44 on Reader Service Card
April 1960

PRODUCT PREVIEW

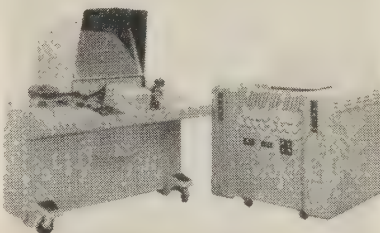
BLACK GLASS encloses semiconductors

A black glass which is impervious to light has been developed for enclosure of silicon semiconductor devices. The glass, designated Code 9361, has physical properties equivalent to the standard clear glass now used by diode manufacturers with a resistivity similar to bulb glass used in standard radio tubes, says Corning Glass Works, Dept. S/A, Corning, N.Y.

The glass has thermal coefficient of expansion of 92×10^{-7} per deg C; Softening point is about 675 deg C; annealing point approximately 495 deg C, and strain point about 455 deg C.

Write in No. 221 on Reader Service Card

FILM READING SYSTEM automatically digitizes



The Dilog 510 semi-automatic film reader with an automatic, high speed electronic digitizing unit accurately measures distances along two axes on 16mm to 70mm sprocketed film. The digitizer is an indicating and reading accumulator which counts and stores measurement pulses generated by the reader, says Telecomputing Corp., Data Instruments Div., Dept. S/A, 12838 Saticoy St., North Hollywood, Calif.

The unit has a counting rate of 20,000 counts per sec with a maximum storage of 100,000 counts along each axis. The reading unit is 52x53.5x36 in. The separate digitizing unit is 32x38x33 in.

Write in No. 222 on Reader Service Card

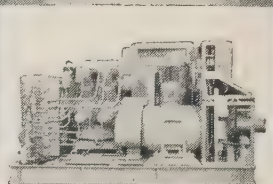
PDM COMMUTATOR in miniature case

Part No. 500602 is a 2 pole 45 BBM channel 20 rps Commutator weighing only 1.8 lbs. In spite of the small size, bounce-free, noise-free 500 hr service has been achieved by new contact and brush materials, says Instrument Development Labs, Inc., Dept. S/A, 67 Mechanic St., Attleboro, Mass.

Brushes are driven through a planetary speed reducing system by a 115 V ac, single phase 400 cycle hysteresis synchronous motor. The sampling system is enclosed in a hermetically sealed case to withstand space, explosive and airborne ambients.

Write in No. 223 on Reader Service Card
more on page 267

JOY COMPRESSOR FOR GROUND SUPPORT BOEING BOMARC



Joy 80 HES
Compressor produces
80 cfm at 5200 psig
75 horsepower

JOY

Joy Manufacturing Company
Oliver Building • Pittsburgh 22, Pa.

Write in No. 45 on Reader Service Card

Advanced hot gas systems delivered by AiResearch

FOR OUTER SPACE, ATMOSPHERIC
AND UNDERWATER
STEERING

Hot gas stabilization control

Hot gas steering control

AiResearch is now in production on two greatly simplified hot gas steering control systems: a reaction control system for outer space flight stabilization and a hot gas actuator control system for terrestrial steering (in the atmosphere and under water).

Both systems eliminate any need for pumps, heat exchangers, accumulators and other apparatus required in earlier control systems. And both systems utilize hot gas, operating off either the main engine or a separate fuel source.

The gas in the outer space reaction control system is fed into a set of nozzles which imparts spin to the missile to stabilize its flight through space.

In the terrestrial hot gas actuator control system the gas is fed into an on-off controlled linear actuator which moves the fins controlling the missile's attitude in the atmosphere or under water. This system also utilizes a concept developed from the AiResearch hydraulic "printed circuit." This approach eliminates complicated plumbing, thereby decreasing the weight and increasing the reliability of the system.

*AiResearch is a pioneer, leading developer and manufacturer of hot gas systems and other nonpropulsive power systems for atmospheric, underwater and outer space missions.
Your inquiries are invited.*

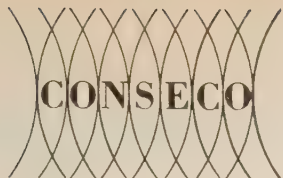
THE GARRETT CORPORATION

AiResearch Manufacturing Divisions

Los Angeles 45, California • Phoenix, Arizona

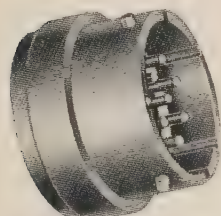
Systems, Packages and Components for: AIRCRAFT, MISSILE, ELECTRONIC, NUCLEAR AND INDUSTRIAL APPLICATIONS
Write in No. 46 on Reader Service Card at start of Product Preview Section

SPACE/AERONAUTICS



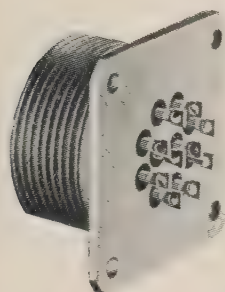
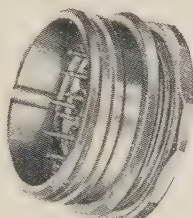
Hermetically Sealed Connectors

CONSECO connectors represent an achievement of more experience in design and manufacture of glass-sealed hermetic items than can be found in any other organization in the United States. This unique, specialized "know how" is at your service in these available units, or for consultation on applications not normally stocked.



**MICON
HERMETIC
SEALED
CONNECTOR**

**MINIATURE
CONNECTOR**



**MULTIPLE
CONTACT
MS
TYPE
CONNECTOR**

Really rugged, CONSECO connectors provide genuine hermetic sealing. They are engineered out of top technical experience to meet military specifications and to perform under the toughest going.

Write for **FREE** literature.

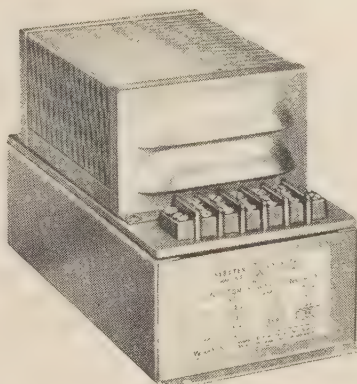
Connector Seals Corp.

300 North Lake Ave. • Pasadena, California
TWX PASA 8584

Write in No. 47 on Reader Service Card
April 1960

PRODUCT PREVIEW

POWER CONVERTERS for aircraft systems

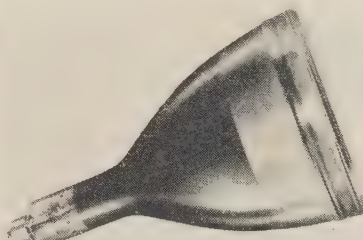


The Models 2D11 and 2D12 transistorized power converters are especially suitable for aircraft electronic systems—particularly radio, according to Webster Electric Co., Dept. S/A, Racine, Wisc. The 2D11 weighs 3½ lbs and is 4¼x4x8 in and the 2D12 weighs 12 oz and is 2x2x4½ in.

The lighter model has the capacity to convert 12 to 250 v dc and the heavier, 12 to 500 v dc. Other advantages besides compactness are easy regulation, absence of moving parts, and overload protection. Efficiency is 75 per cent full load and ripple is under one per cent full load for both models.

Write in No. 224 on Reader Service Card

RADAR TUBES have fast sweep

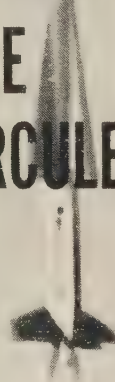


This radar tube line features ultra-fast electrostatic deflection and focus for accurate and complete surveillance of fast moving objects. The tubes offer jump-sweep capabilities to meet modern radar read-out requirement including high resolution, deflection uniformity, and reduced deflection defocusing, says Allen B. DuMont Labs., Inc., Dept. S/A, 750 Bloomfield Ave., Clinton, N.J.

A 16 in tube has a minimum useful screen diameter of 14½ in. Typical operating conditions are accelerator voltage of 10,000 volts; focusing electrode, 3000 to 3500 volts; modulation, 40; and line width, 0.015 in. Tubes are available also in 10 and 12 in. sizes.

Write in No. 225 on Reader Service Card
more on page 269

JOY FANS FOR ELECTRONIC COOLING NIKE HERCULES



Fan No. X702-202A
Supplies 300 cfm
at 3" WG pressure
.25 hp

JOY

Joy Manufacturing Company
Oliver Building • Pittsburgh 22, Pa.

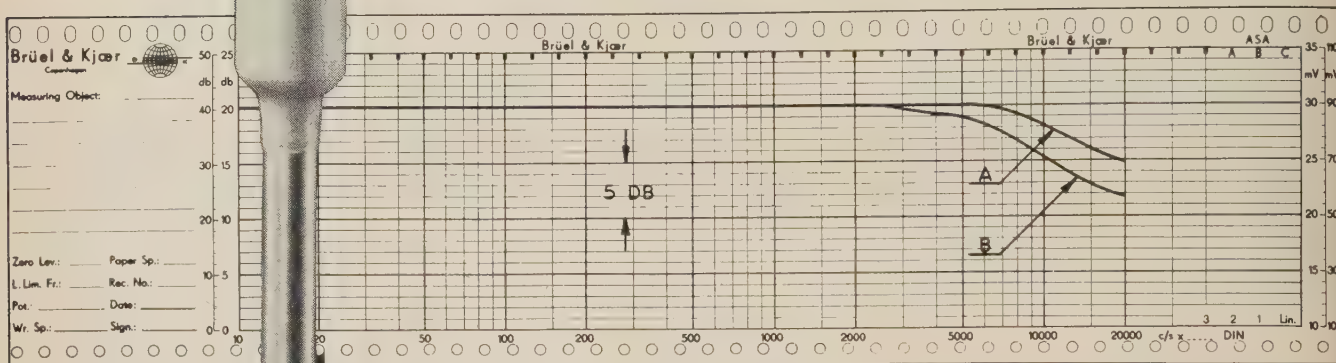
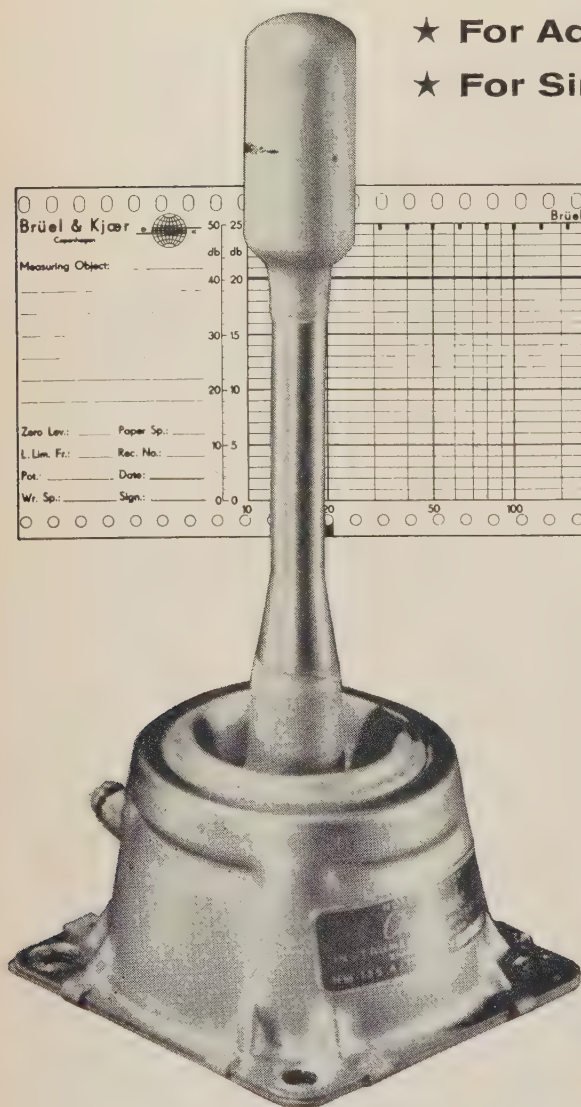
Write in No. 48 on Reader Service Card

B & K Instruments Introduces:

NEW HIGH INTENSITY MICROPHONE

★ For Adverse Test Environments

★ For Simple, Foolproof Noise Measurements



A. Typical Free Field Response for Model NM 125

B. Typical Free Field Response for Model NM 135

measure "in flight" and
test stand acoustic
environments as simply
as acceleration

Model NM 125 — 4 inches high

Model NM 135 — 5 $\frac{3}{4}$ inches high

★ Self-Generating Sensor

★ Low Sensitivity to Shock & Vibration

★ Temperature Range -75° to +500° F.

★ Dynamic Range 90 to 200 db.

★ Unaffected by Weather

Gentlemen:

Please send me

☐ NM 135 Microphone Brochure

☐ B & K Complete Line Catalog

NAME _____

COMPANY _____

ADDRESS _____

CITY _____ ZONE _____ STATE _____



B & K INSTRUMENTS, Inc.

3040 W. 106th STREET • CLEVELAND 11, OHIO • Clearwater 1-8430

Write in No. 49 on Reader Service Card at start of Product Preview Section

B.F. Goodrich

RUGGED FUEL HOSE

BFG hose for fuel, oil, and coolant lines is ruggedly built with multiple braids for high strength and burst resistance. Type H-100 all purpose type, sizes 1/4" through 4" I.D. Type A0-19 fire resistant type for fuel and oil lines ahead of engine fire wall, sizes 1/4" through 2" I.D. For fuel, De-Icer, or instrument line hose check B.F. Goodrich.

B.F. Goodrich aviation products

Dept. SA-4, Akron, Ohio

Write in No. 80 on Reader Service Card

B.F. Goodrich



Pressure seal zips open fast

The B.F. Goodrich Pressure Sealing Zipper seals out liquids, gas, air, and dirt. Precision fit of the special rubber lips makes a tight seal, even around curves and corners. Opens quickly—like an ordinary Zipper. Use for inspection covers, bulkheads, air ducts, panels, and other parts for easy access.

B.F. Goodrich aviation products

Dept. SA-4, Akron, Ohio

Write in No. 81 on Reader Service Card

April 1960

PRODUCT PREVIEW

MULTICODER in compact design

The design of the Model 1208D-2 PDM Multicoder has resulted in a 4 x 4 x 4-in device that samples 88 instrument channels and simultaneously produces PDM and PAM output waveforms, says General Devices, Inc., Dept. S/A, P.O. Box 253, Princeton, N.J. The all-electronic unit, which is built to withstand space-vehicle environments, will drive a standard magnetic record head from the PDM output and a standard SCO from the PAM output.

All necessary auxiliary power supplies and blanking and keying circuitry are contained in the solid state device, and it operates directly from a nominal 28-V supply drawing three W.

Write in No. 226 on Reader Service Card

TIME DELAY RELAY used in Explorer VI



This relay performs an important switching function at a predetermined time after energizing. It is designed to operate on minimum power and to be as small and light weight as possible, according to P. R. Mallory Co., Inc., Dept. S/A, 3024 E. Washington St., Indianapolis, Inc.

The unit was used in the Explorer VI.

Write in No. 227 on Reader Service Card

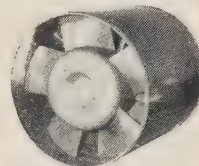
TRANSDUCER for tilt angle

This Electronic Tilt Angle Transducer is an optical-electronic device capable of automatically detecting and recording angular change to within 1/4 second of an arc, a degree of accuracy unattainable by other methods, states Keuffel & Esser Co., Dept. S/A, Hoboken, N.J. The instrument can be used to measure positional disturbances of structures such as guided missile launching platforms radar tracking systems.

Used on a launching platform, the disturbance signal from the instrument can be fed directly into a servo-mechanism to make the platform self-leveling. In long-range radar tracking, it is capable of monitoring the motion of the axles and recording, with a time index, the information needed to correct the basic data.

Write in No. 228 on Reader Service Card
more on page 271

JOY FANS FOR FLIGHT STATION RECIRCULATION LOCKHEED ELECTRA



Fan No. X702-259
Supplies 410 cfm
at 5.1" WGs
using 0.5 hp

JOY

Joy Manufacturing Company
Oliver Building • Pittsburgh 22, Pa.

Write in No. 82 on Reader Service Card

*New from the Ground Support Division
of American Electronics, Inc.*

FEATHERWEIGHT TRAILER

carries over 20 times its weight!



Shown as a working combination are three new products of American Electronics' Ground Support Division:

A featherweight 105 lb. transportation trailer capable of carrying loads up to 2500 lbs. such as the new light engines for aircraft, helicopters and drones; missile sub-assemblies, instrumentation packages, nose cones and other components. With 30" track, rail stops, couplings, towbar.

A featherweight maintenance stand—a matching unit that hooks up with the trailer—weighs only 55 lbs. yet supports 1¼ tons. Although 6 ft. in length, 24 inches in height, and standard 30-inch rail gauge, this light, versatile stand can be easily carried and handled by one man.

A revolutionary new lightweight shipping container for engines, missile and aircraft components, 40" in diameter, 80" in length. This rugged, light container fits standard USAF trailers—is made of a rigid, heat-formed, expanded material for maximum protection and ease of handling.

These new units are examples of a long line of universal design developments by the Ground Support Division of American Electronics. Years of such experience has established American Electronics' leadership in the field of ground support equipment and systems for missiles and aircraft.

Please write for complete details on the above support units and for our new 24-page brochure on Ground Support Equipment.

Engineering
opportunities
are available



AMERICAN ELECTRONICS, INC.

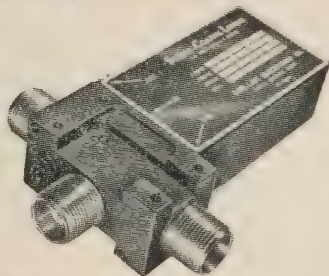
GROUND SUPPORT DIVISION

2112 NORTH CHICO AVENUE, EL MONTE, CALIFORNIA

PRODUCERS OF PORTABLE POWER • AIR CONDITIONING • MECHANICAL SUPPORT • ELECTRONIC SUPPORT • GROUND SUPPORT SYSTEMS

Write in No. 83 on Reader Service Card at start of Product Preview Section

MINIATURIZED RF COAXIAL LOBING SWITCH



- WEIGHT 0.7 lbs. (SP2T model)
- BROADBAND — DC to 10,000 mc
- NOISE-FREE OPERATION
- "MAKE" before "BREAK" operation
- LIFE 1,000 hours
- HERMETICALLY SEALED
- CHOICE OF "N," "HN" or "SC" RF Connector
- LOW COST
- EXCELLENT RF CHARACTERISTICS square-wave operation

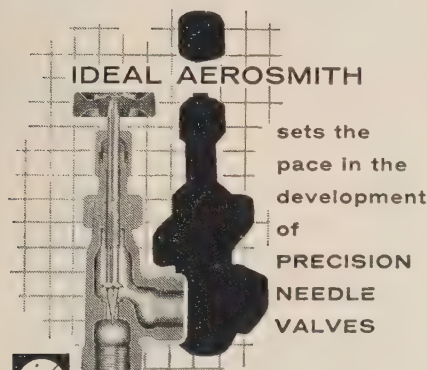
\$236 (quantity prices upon request)

DON-LANelectronics, inc.

1101 olympic blvd., santa monica, calif.

division of Regan Industries, Inc.

Write in No. 84 on Reader Service Card



IDEAL Aerosmith is the leader in the designing and building of Precision valves for critical control or metering of liquids or gases.

LOOK FOR THESE FEATURES:

- Micrometer type vernier scales available on most sizes and models for consistent repeatability.
- Exclusive IDEAL design: Precise control is assured by the slim taper of the needle. Twenty turns for full open.
- Available in Bronze or 18-8 stainless steel.
- Available in 1/8" to 1/2" pipe size.
- Teflon seating available. Special valves built on request.

Some choice distributorships are still available

IDEAL AEROSMITH

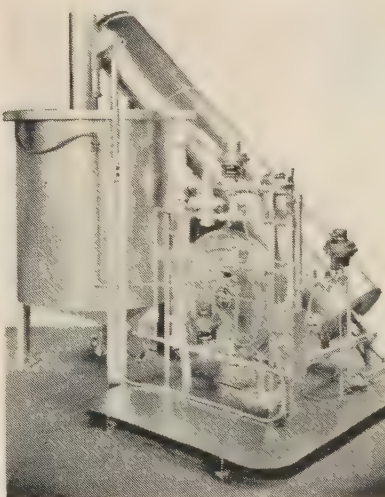
A Subsidiary of Royal Industries
CHEYENNE, WYOMING

Write in No. 85 on Reader Service Card

April 1960

PRODUCT PREVIEW

TEST FURNACE for high temperatures

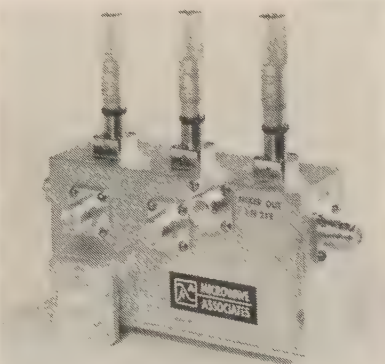


This gas-fired furnace of wide operating temperature range for laboratory and research use was developed to determine thermocouple reliability at temperatures above 3000 deg F. The furnace has specially designed burners that require no water cooling and which use a standard 16 oz blower, says Hirt Combustion Engineers, Dept. S/A, 1633 Bluff Rd., Montebello, Calif.

It has a heating chamber of 6 in in diameter and 6 in high.

Write in No. 229 on Reader Service Card

PARAMETRIC AMPLIFIERS for L-band



Models MA 2-1000 for the 950-1250 Mc range and model MA 2-1000L for the 1250-1350 Mc range are both Parametric Amplifier mixer, down-converter units for very low noise signal reception. Both models exhibit noise figures below 2 db with bandwidth of 0.25 per cent, says Microwave Associates, Inc., Dept. S/A, Burlington, Mass.

Image rejection is better than 50 db down, and dynamic range is 80 db or better. Precision micrometer drive controls facilitate accurate tuning adjustment. The basic dimensions are 6x3x2 in.

Write in No. 230 on Reader Service Card
more on page 273

JOY FANS FOR ELECTRONIC COOLING IN FLIGHT NORTHROP SNARK



Fan No. X702-112E
Supplies 3270 cfm
at 7" WGP's
10/6 hp

JOY

Joy Manufacturing Company
Oliver Building • Pittsburgh 22, Pa.

Write in No. 86 on Reader Service Card



**READY FOR
DELIVERY**

C.O.D.

RELIABILITY IS THE TARGET

The moment of truth for a missile occurs at the instant of detonation and the C.O.D. we speak of is Confidence of Detonation.

For programmed detonation, missile fuzing in all of its complex phases . . . safing, arming, firing . . . must provide the ultimate in RELIABILITY and PRECISION. To achieve these goals in such a highly specialized field, Reeves has established a separate plant area, fully staffed and equipped, and devoted exclusively to the design, development and fabrication of advanced fuzing components and systems.

Whether your requirements are for complete fuzing systems or precision subassemblies, it will be worth your while to contact Reeves.

Qualified engineers seeking rewarding opportunities in these advanced fields are invited to get in touch with us.



REEVES INSTRUMENT CORPORATION

A Subsidiary of Dynamics Corporation of America
Roosevelt Field, Garden City, New York

Write in No. 87 on Reader Service Card at start of Product Preview Section

SPACE/AERONAUTICS

SECURITY

Is classified security a requisite for your film processing? It's guaranteed when you specify Consolidated Film Industries...the nation's leading film processor for over 40 years.

Setting standards for the industry, CFI is still pioneering in the latest security practices. Black and white or color, your test data, training and visual aids films are under stringent security at all times.

For 16 or 35 mm, CFI developed and employs the most modern processing equipment. A broad range of special effects are available to meet every requirement.

CFI does not compromise on quality. Only the finest product receives our Quality Control approval.

CFI, long noted for dependable, fast delivery, serves many major aircraft and missile companies. For your convenience CFI maintains film processing facilities in New York and Hollywood. For the best in service and quality specify CFI. Call or write today for complete information!

CONSOLIDATED FILM INDUSTRIES

959 Seward St., Hollywood 38, Calif. • HO 9-1441
521 West 57th St., New York 19, N.Y. • CI 6-0210



PRODUCT PREVIEW

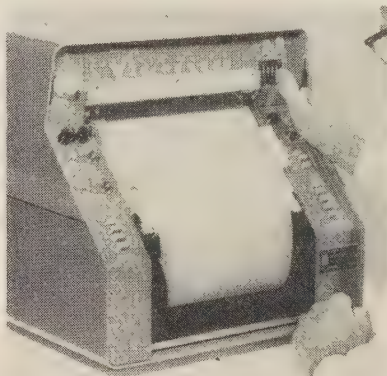
DELAY LINE has short delay period

Type CLN-150-30, a lumped constant delay line has a delay time of 0.3 microsec ± 5 per cent. The delay line has an impedance of 150 ohms and a maximum rise time of 0.08 microsec, says Technitrol Engineering Co., Dept. S/A, 1952 E. Allegheny Ave., Philadelphia, Pa.

Pulse attenuation is 1.0 db maximum and the operating temperature ranges from -55 to $+85$ deg C. The unit is hermetically sealed and measures 2 3/8 x 5/8 x 1 11/32 in.

Write in No. 231 on Reader Service Card

OSCILLOGRAPH features 24 channels



Model 1108 Visicorder permits high-speed recording of up to 24 channels of data simultaneously. Frequency range is from DC to 5000 cps, says Minneapolis-Honeywell Regulator Co., Heiland Div., Dept. S/A, 5200 Evans Ave, Denver 22, Colo.

Chart speeds are pushbutton-selected and are adjustable in 15 variations from 0.1 to 80 ips. This model, as well as the other Visicorder models is a dry and dustless duct-recording oscillograph that produces instantly-readable records.

Write in No. 232 on Reader Service Card

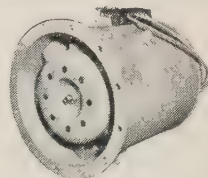
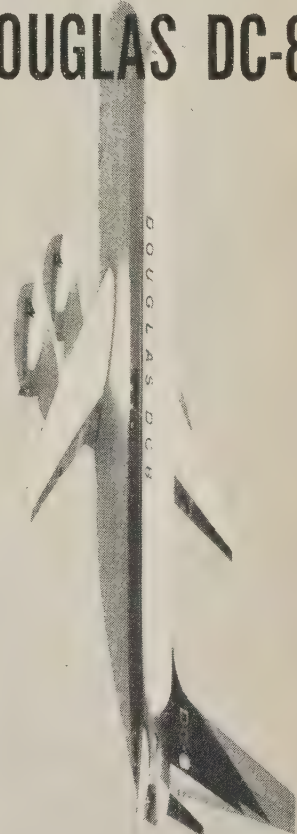
INSTRUMENT VALVE has low torque

This instrument valve has fine metering characteristics and low operating torque and is said to be excellent for control of manometers and gauges. Operating torque at 1000 psi 1" pound; at 3000 psi 4" pounds. O-ring seal spindle, plastic seat, bubble tight shut-off, says Robbins Aviation, Inc., Dept. S/A, 2350 E. 38 St., Los Angeles 58, Calif. It is said that over-torquing cannot damage metering pin or seat because the positive shut-off is a flat disc against the plastic seat.

It has a brass body and 303 stainless steel spindle barrel and spindle. Working pressure of absolute vacuum to 3500 psi. Temperature range of -450° F to $+500^{\circ}$ F.

Write in No. 233 on Reader Service Card
more on page 275

JOY FANS FOR CABIN VENTILATION DOUGLAS DC-8



Fan No. X702-256C
supplies 2170
at 23.5 WGP's using
only 11.0 hp

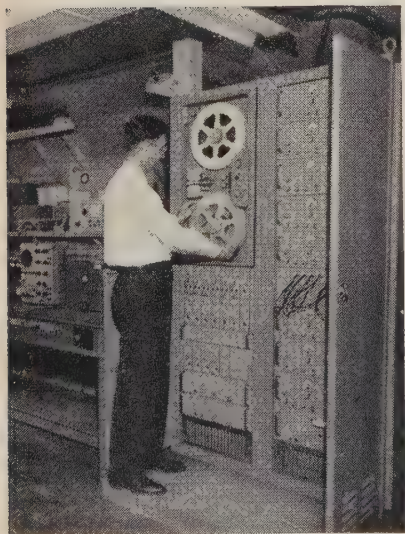
JOY

Joy Manufacturing Company
Oliver Building • Pittsburgh 22, Pa.

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NAVY USES HONEYWELL SYSTEM TO "CATCH" TV SIGNALS BOUNCED OFF TROPOSPHERE



(Official U. S. Navy photographs)

To determine the effects of frequency, distance, antenna size and scatter angle on TV and other wide-band transmission by means of tropospheric scatter links, the U. S. Navy Electronics Laboratory in San Diego, is using a 14-channel Honeywell Series 3170 Magnetic Tape System to record this valuable data.

Microwave propagation paths of 90 and 190 miles and frequencies of 1300, 3400 and 9400 megacycles are used for these studies. Peak values are recorded on magnetic tape as signals varying between 0 to 100 cps. The frequency of this signal represents the fading rate of the incoming microwave signal.

The recorded data can be played back to determine power spectrum, amplitude distribution and median signal level. The simplified speed control of the Honeywell system makes it easy to slow down the data for analog computation and digital analysis.

The unique features of the Honeywell Series 3170 System can also provide an efficient solution to your data recording problem. For the full story on a system tailored to your needs, just give your Honeywell field engineer a call. MINNEAPOLIS-HONEYWELL, 10721 Hanna Street, Beltsville, Md.

Honeywell



First in Control
SINCE 1885

75th
PIONEERING THE FUTURE
YEAR

Write in No. 90 on Reader Service Card at start of Product Preview Section

SPACE/AERONAUTICS

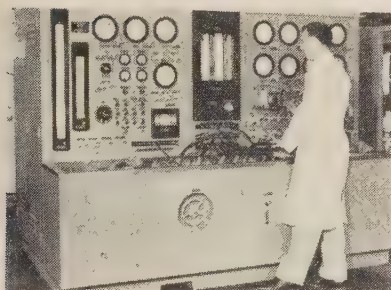
COMPARATOR for ac-dc voltage

This go, no-go voltage comparator actuates upon the relationship of two input signals, V_a and V_b , says **Optimized Devices, Inc.**, Dept. S/A, 864 Franklin Ave., Thornwood, N. Y. Go conditions result in the connection.

Typical applications include system performance evaluation, continuous monitoring, automatic checkout, automatic control combination to perform the operations of automatic grading, sorting, classifying or other discrete evaluations, it is said.

Write in No. 234 on Reader Service Card

TEST STAND for aircraft hydraulics



This universal hydraulic components test stand, model 9510, for simulated flight condition testing of airframe hydraulic components is self-contained. It has three hydraulic pumps. The main pump, a variable volume unit, is driven by a 40 hp motor and supplies 20 gpm flow at 3000 psi. An auxiliary develops 10 gpm at 50 psi. For high pressure static testing an air-operated hydraulic intensifier produces 9000 psi, says **George L. Nankervis Co.**, Dept. S/A, 15400 Fullerton Ave., Detroit 27, Mich. A nitrogen system within the stand is used for high pressure static testing.

It contains a high pressure proof testing chamber.

Write in No. 235 on Reader Service Card

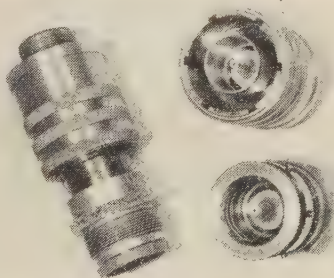
PRESSURE PICKUP for missiles

Model 4-380A is a potentiometer pressure pickup that will operate in such missile conditions as high-g acceleration and vibration for sustained periods. It will withstand 100 G shock and static acceleration on three orthogonal axes without damage or unusual response, says **Consolidated Electrodynamics Corp.**, Dept. S/A, Sierra Madre Villa, Pasadena, Calif.

In addition the instrument is built to operate in vibration environments up to 25 G for many hours and throughout the frequency band to 3 Kc. Operational temperature range is from -65 deg F to 200 deg F. Maximum temperature is 300 deg F.

Write in No. 236 on Reader Service Card

CIRCUIT ANALYZER has large capacity



Up to 2000 two-terminal missile or computer circuits may be automatically checked in a pre-determined sequence by the Model 501 multiple circuit analyzer, says **Consolidated Avionics Corp.**, Dept. S/A, 800 Shames Dr., Westbury, N.Y. The device prints out the type of failure when a defect in wiring or insulation is located.

The equipment, which indicates by numerical display the circuit being measured, can also check out 800 multi-term networks, 400 of which can be relay controlled. Series resistances from one to 1000 ohms are measured by means of 28 V dc and leakage resistance at 28 or 500 V dc. The time required for each circuit check varies from 0.1 to ten sec, depending on factors such as the decay of insulation values with time. Features include unusual operational flexibility and a self-checking test that follows each analyzer step during circuit checks.

Write in No. 237 on Reader Service Card

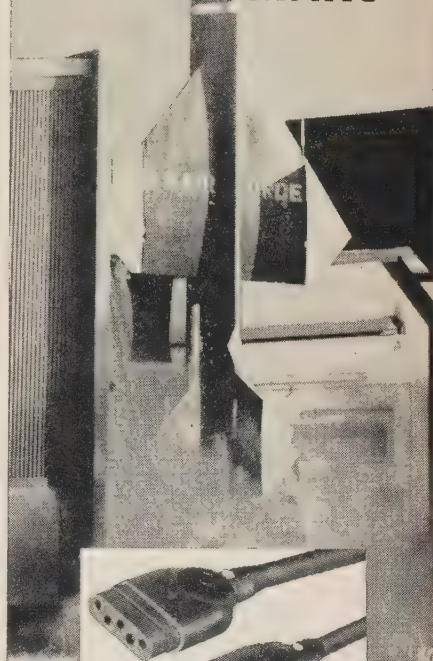
RADAR BEACON is transistorized

Transistorization has been used in an airborne, pulse-type missile tracking and identification C-band radar beacon designed for operation with the AN/FPS-16 radar but compatible with several others, says **General Electric Co.**, Dept. S/A, Schenectady 5, N.Y. The device transmits a single RF pulse in response to a coded rf interrogation signal.

The 9.8-lb unit consists of a tunable duplexer, crystal mixer, tunable local oscillator, intermediate frequency amplifier and detector, video-decoder, modulator, tunable magnetron, and power supply. Only the oscillator and magnetron are not transistorized. Supply voltage needed is 28 V dc, and power drain is about 25 W at a 2000-pps rate. The interrogation signal can use any discrete frequency in the 5400 to 5900-mc range, and pulse width is 0.25 usec minimum between 50 per cent amplitude points. Dynamic range of the receiver is zero to -65 dbm, and a signal level of +20 dbm will not damage the equipment.

Write in No. 238 on Reader Service Card
more on next page

JOY WATERPROOF ELECTRICAL CONNECTORS PROVIDE RUGGED RELIABILITY FOR BOMARC

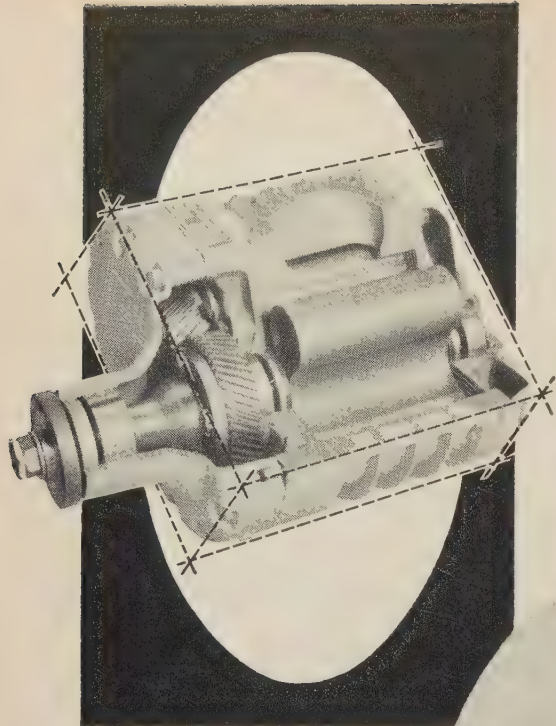


Integral design for dependable performance under the most demanding operating conditions of ground support equipment. Custom-design recommendations and technical assistance on request.

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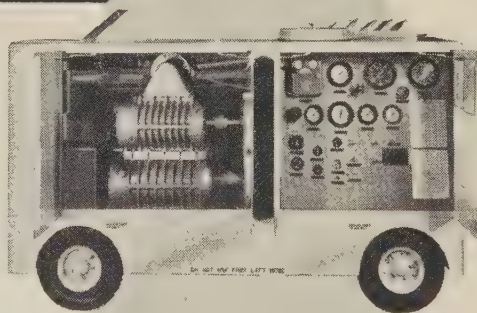
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**delivers
1,000 cfm
(up to 14 psig)**

**takes
less than
5½ cu. ft.**

**Arnolt Corp. Model CPT6-O
TESTER, PRESSURE CABIN
LEAKAGE (For Military
and Civilian Aircraft)**
Utilizes 2-stage M-D Blower Unit
1000 SCFM—10 PSIG
800 SCFM—12.5 PSIG
600 SCFM—14.0 PSIG



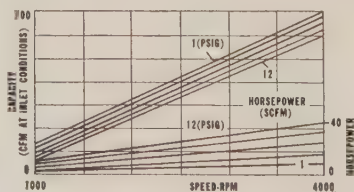
**ARNOLT CORPORATION FINDS M-D ROTARY
POSITIVE BLOWERS USE LESS H.P.—
EFFICIENT AT WIDE SPEED RANGE**

The Arnolt Corp. employs a 2-stage M-D blower in their cabin pressure leakage tester for several reasons. It does the job with 50% reserve capacity, takes up a fraction of the space of competitive blowers with equal capacity, operates efficiently at any speed or pressure and requires a smaller driver.

If space and weight of the blower is a concern in your design problem, consider this fact. M-D rotary positive blowers because of their unique 3-lobe design require

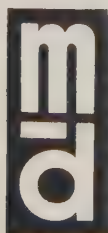
smaller cubic space than any other blowers. A survey shows that a 10 PSI M-D takes ¾ to less than 1/10 the space of competitive models . . . and in some cases are only 1/10 the weight.

M-D Blowers operate at wider pressure and speed ranges than any other rotary positive blower. The capacity of the Model 4012 (4" rotor 12" long) is shown below. Capacities of 11 other production models range from 50 to 4000 CFM, pressures to 14 PSIG single, 70 PSIG multi-stage.



For full information write

M-D BLOWERS, INC., RACINE, WISCONSIN
A Subsidiary of **Miehle-Goss-Dexter, Inc.**



Write in No. 92 on Reader Service Card at start of Product Preview Section

PRODUCT PREVIEW

**SERVO ANALYZER
generates square waves**

This servo analyzer has wide frequency coverage and the integrator is said to contribute accuracy and stability. Frequencies are indicated on a 4 in dial that permits readout over entire range. A special circuit design is used for generating square waves, assuring transient-free wave forms even at extremely low frequencies, according to **Aetna Electronics Corp., Dept. S/A, Readington Rd., N. Branch, N. J.** A 100 to 1 attenuator is provided.

Both front and rear of the cabinet are equipped with output terminals. The analyzer will accept carrier frequencies from 50 to 5000 cycles and has an internal carrier source of 5000 cycles.

Write in No. 239 on Reader Service Card

**DAMPER
for eddy current**

This damper is designed for control of undesirable forces such as overtravel motions, oscillation, force surges and unstable speeds. Designated as model 1054, it is self-contained, non-friction, and non-hydraulic, says **Lyndon Aircraft, Inc., Dept. S/A, 140-15 Clifford St., Newark 5, N. J.** It has a damping rate of 40 in lb/rad/sec; inertia of 0.033 slug-ft²; peak input velocity of 4.0 rad/sec; breakout torque of 1.0 in lb max; rotation of through 360 deg; backlash of ¼ deg, max.; and operates within a normal operating range of -65 deg F through +165 deg F.

Its weight is 2.8 lbs. It has an externally adjustable overload protective clutch with a torque setting of 40 in lb +10-20 lbs.

Write in No. 240 on Reader Service Card

**REFUELING SYSTEM
is versatile**

Ground refueling of jet transport carrying nearly 22,000 gallons of kerosene can be accomplished with a pressure refueling system manufactured by **Parker Aircraft Co., Dept. S/A, 5827 W. Century Blvd., Los Angeles 45, Calif.** Equipment is being built both for the static, hydrant-type fueling operations, it is said, as well as for mobile, tank-truck installations.

The technique calls for a recessed or underground hydrant that contains the various control devices. These regulate the rate of transfer from underground tanks into the aircraft. Included is a "deadman" control that enables the operator to remotely control an emergency shutdown, refueling nozzles that fit into the underside of the jet's wing, and associated adapters, couplers, regulators and valves.

Write in No. 241 on Reader Service Card
more on page 27



From the era of the "\$2 ride" to today's million dollar blast off's, the success of air vehicle performance has hinged on the reliability of components. Since 1933, Pesco products have been acclaimed for their proven dependability. As man prepares to meet the new challenges of flight, imaginative Pesco engineers are developing new concepts of reliability and . . . through creative engineering . . . are translating them into precision components to deliver volatile fuel, control the flow of hydraulic power, actuate guidance devices, generate and convert precise power, and cool vital working parts. Because today's high mach aircraft demand fail-safe operation, Pesco designs and builds components to *meet and exceed* all anticipated requirements to provide assured performance under critical operating conditions.

**PESCO PRODUCTS ASSURE RELIABLE PERFORMANCE
FOR AIRCRAFT, MISSILES, AND SPACECRAFT**



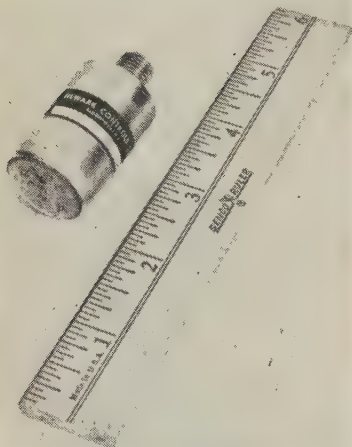
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BORG-WARNER CORPORATION**
24700 North Miles Road • Bedford, Ohio

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YOUR SPECIALIZED REQUIREMENTS IN . . .

- STATIC INVERTERS
- FREQUENCY CHANGERS
- CRYOGENIC COMPONENTS
- ENVIRONMENTAL COOLING
- AUXILIARY POWER SYSTEMS
- ELECTRIC POWER GENERATION

EXPORT SALES: Borg-Warner International Corp., 36 South Wobash Avenue, Chicago 3, Illinois
Write in No. 358 on Reader Service Card at start of Product Preview Section

PRESSURE SWITCH is miniaturized

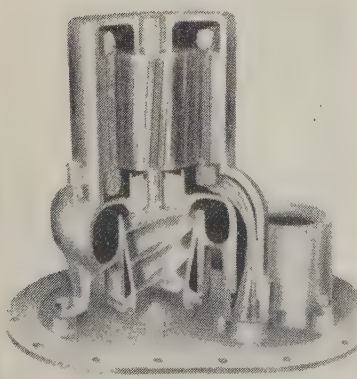


Model RR-58 is a high temperature, subminiature absolute air pressure switch. The unit is available in an actuating pressure range of 5 to 30 psia, says Newark Controls Co., Dept. S/A, 15 Ward St., Bloomfield, N. J.

Able to perform in a temperature range of -85 to 400 deg F, the switch has an accuracy of ± 0.5 psi from -85 to +185 deg F and ± 1.5 psi from 185 to 400 deg F. Weighing less than 1.8 oz and measuring $1\frac{27}{32}$ in length and $\frac{7}{8}$ in diam, the unit meets stringent environmental specification.

Write in No. 418 on Reader Service Card

FUEL PUMPS use modular design



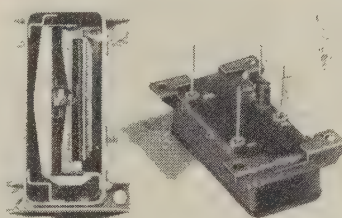
The two basic sizes of these centrifugal fuel pumps for military and transport aircraft utilize modular construction to provide an overall performance spread from ten to 250 gpm, says Adel Precision Products, Dept. S/A, 10777 Vanowen St., Burbank, Calif. The different capacities are obtained by modification of impeller and motor stack length, and the design

permits customized mounting since mounting plate, pump body, and motor cover are separate units.

The pumps, which cover the performance range without the need of a pressure relief valve, are available in either ac motor drive or hydraulic motor drive types.

Write in No. 419 on Reader Service Card

MISSILE TIME DELAY is high precision device



A thermal time delay for missile use may be operated under vibration of 20 g up to 2000 cps and under shock of 50 g for 11 msec, says G-V Controls, Inc., Dept. S/A, Okner Pkwy, Livingston, N.J. The Type PT, which provides higher precision than has been available before, has no resonance below 2000 cps and resists temperature effects over a -65 to +125 deg C ambient range.

Factory-set operating time delays are available from three to 60 sec, within a tolerance of plus or minus five per cent. The relays are hermetically sealed in a rectangular case, and leads located on 0.2-in. spacing project through the bottom of the case. Contacts are spst, either normally open or normally closed, and they are rated at two amps resistive at 115 V ac or 28 V dc. Dielectric strength at 70,000 ft is 500 V.

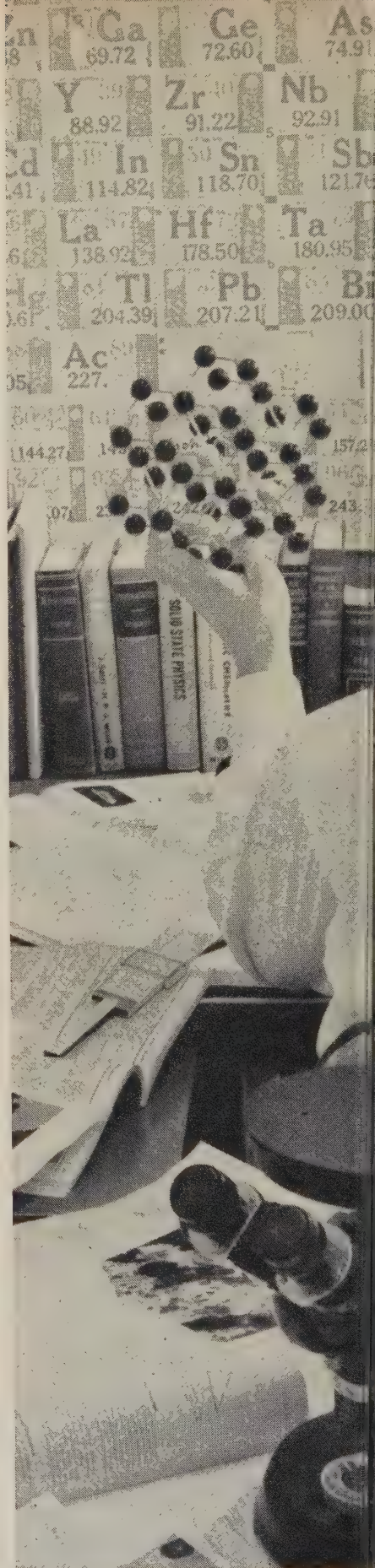
Write in No. 420 on Reader Service Card

STRAIN GAGE CEMENT for service to 400 deg F

These epoxy cements were formulated for use with bonded filament strain gages to bond the small, postage-stamp size gages firmly to any test material. They are designated as EPY-150 and 400, and have maximum service temperatures of 150 deg F and 400 deg F, respectively, says Baldwin-Lima-Hamilton Corp., Electronics & Instrumentation Div., Dept. S/A, 42 Fourth Ave., Waltham 54, Mass. Both types are in small plastic packs, each divided into two compartments containing the liquid adhesive and activator. The cement is mixed for use.

EPY-150 is available in boxes of ten 6, 8-gm plastic packs. The 400 is supplied in boxes containing three 20-gm packs or one 100-gm pack. Shelf life is six months or more.

Write in No. 421 on Reader Service Card
more on page 280



MOTOROLA



DAY DREAMS & NIGHT SHIFTS

CAPABILITY throughout the spectrum of creative research to practical production, from *day dreams to night shifts*, is a sum of the qualitative and quantitative input of Motorola's Military Electronics Division. Its breadth and depth is evident in personnel and facilities at every echelon...from advancing frontiers of the art in Solid State electronics to volume production of anti-submarine warfare devices. Moreover, all of Motorola's military electronic capabilities have this common denominator: uncompromising reliability of final performance.

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Engineers, scientists and qualified technicians seeking challenging opportunities in a dynamic organization are invited to write Motorola. Address your inquiry to the area of your choice:

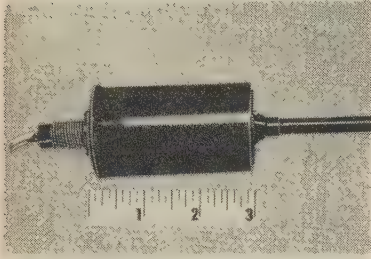
Military Electronics Division



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SCOTTSDALE, ARIZONA
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8330 INDIANA AVENUE

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**WARNING SWITCH
weighs 5 ounces**



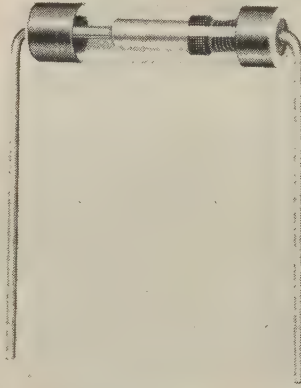
This explosion proof, hermetically sealed, low-level warning switch is for use in almost any liquid, and can be installed to warning lights and/or automatic switching mechanisms to start pumps or open auxiliary lines. It cannot be fouled by contamination of fluid and is said to be unaffected by rolling or pitching motions, according to Acme Machine Works' Divac Div., Dept. S/A, 13025 Cerise, Hawthorne, Calif. A time lag mechanism prevents

tripping when upside down for less than 3 sec.

Specifications include: meets military specification f-86-15; operates on standard electrical system; temperature from -65° to $+250^{\circ}\text{F}$.

Write in No. 422 on Reader Service Card

**SENSITIVE FUSE
is highly reliable**



This current-sensitive fuse having a functional reliability of 99.99 per cent is glass enclosed and hermetically

sealed. The fuse is 100% humidity proof and will meet any specified resistance to atmospheric conditions, according to Networks Electronic Corp., Dept. S/A, Van Nuys, Calif. It withstands temperatures from -100°F to $+400^{\circ}\text{F}$, vibration of 10 to 500 cps at 15 g's maximum, and shock of 50 g's for 11 milliseconds.

The fuse is dimensioned to dissipate heat produced by the maximum rated current under any special blowing time and temperature conditions.

Write in No. 423 on Reader Service Card

**RADAR BEACON
built for C-Band**

Designed as an airborne, pulse-type tracking and identification aid for missile applications, this transistorized radar beacon weighs only 9.8 lb. The unit is capable of 400 watts output and occupies only $1/7$ cu ft, according to General Electric, Dept. S/A, Schenectady 5, N.Y.

Although continuously tuneable in the C-band area, 5400 to 5900 Mc, the beacon can be adapted for other radars and frequency ranges.

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Whittaker Controls
PLANNED
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SUCCESS

FAILURE

FIRE

DESTRUCT

SINCE 1942, WHITTAKER CONTROLS HAS BUILT OVER 2,000,000 CONTROL DEVICES

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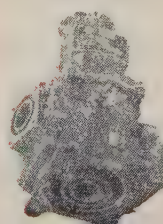
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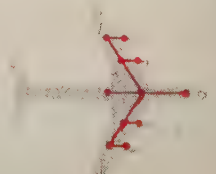
PNEUMATIC



FUEL

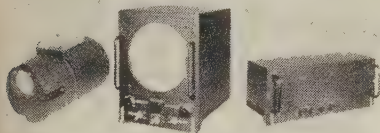


FLUID CONTROL SYSTEMS



TV SYSTEM is completely transistorized

Designated MTS-4, this is said to be the first completely transistorized, ruggedized television system which makes possible the use of closed-circuit TV for military purposes. It is engineered to meet adverse environment specifications and to be functionally reliable and easy to



maintain, says Thompson Ramo Woodridge, Inc., Dage Television Div., Dept. S/A, Michigan City, Ind.

The entire system weighs only 55 lb and consists of three components: a television camera, a television monitor, and a television control, which provides power and synchronization to both camera and monitor. Operating controls do not require more than one adjustment after a

½-hr warm-up, and the system will perform within specifications for at least 8 hr after warm-up without adjustment of controls not easily accessible.

Write in No. 425 on Reader Service Card

PRESSURE TRANSDUCER is miniature size

This miniature airborne pressure transducer of stainless steel construction permits measurement of corrosive fluid and gas pressures up to 1000 psi. Permanent bonding of the strain gages to the surfaces of the proving ring result in the resistance gages becoming an integral part of the sensing element, eliminating vibration effects on the gages, says Taber Instrument Corp., Electronics Div., Dept. S/A, No. Tonawanda, N.Y. The ring also provides a heat sink for the normal heating of the resistance gages and a conduction path in the instrument case.

It is said to have low sensitivity to vibration, infinite resolution, high overload capacity, and a pressure cavity clean-out feature.

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more on next page

RELIABILITY

Product reliability must be planned. At Whittaker Controls, reliability planning starts with design and engineering...and is a vital part of every operation from Concept to Customer!

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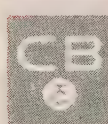
ELECTRONIC SYSTEMS: Specialists in system management, this Division also designs and manufactures a wide variety of equipment in the fields of electronics and nucleonics for highly classified Military Programs. In addition, Electronic Systems designs and produces Air Traffic Control equipment for the Federal Aviation Agency.



DATA INSTRUMENTS: Leading designer and producer of data reduction systems for ground support and range instrumentations. Product line includes shaft rotation digital equipment, decommutators, and other highly complex and specialized instruments for missile and aircraft testing, telemetering and in-flight operation.



ELECTRONIC COMPONENTS: Designs and produces components, including magnetic amplifiers, transformers, micro-miniature relays, delay lines and high temperature ceramic capacitors. These reliable components are being selected for installation in many of the country's principal missile and space programs.



COOK BATTERIES: Designers and manufacturers of automatically and manually activated silver zinc batteries for specialized missile application. These auxiliary power units provide primary or secondary electrical power. This subsidiary also produces power conversion and other electronic apparatus.

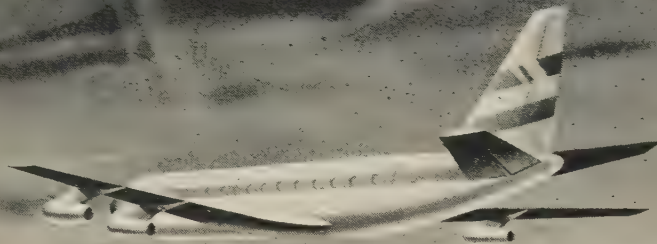
TELECOMPUTING CORPORATION

Los Angeles, California

Telecomputing Corporation is a unique combination of carefully integrated organizations. It is staffed with scientific talent of rare ability, created for the purpose of managing entire Space Technology and Weapon System Projects. Telecomputing is developing advanced concepts in industrial and military control systems.

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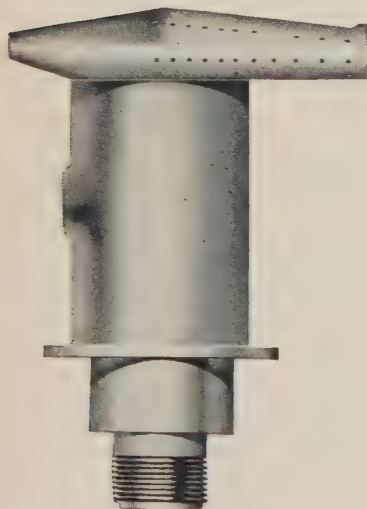
optimum CRUISE CONTROL...



**CAN BE OBTAINED
THROUGH THE USE OF REC'S
ALL WEATHER MODEL 102 Series
TOTAL TEMPERATURE PROBE.**

FAST AND ACCURATE . . . THE 102U HAS THE ABILITY TO MEASURE TOTAL TEMPERATURE WHILE DEICING HEAT IS CONTINUOUSLY APPLIED.

BENEFICAL USES



Model 102 U
(ONE HALF SIZE)

- To select engine power settings and flight altitude for best economy and safety.
- To monitor engine performance—when used in combination with engine speed and pressure ratio. (to detect engine malfunction)
- To calculate true airspeed (in combination with Mach number) for air navigation.
- To indicate total temperature, for miscellaneous purposes. For example, to indicate icing temperatures.
- To locate jet stream.

FOR FURTHER INFORMATION
WRITE FOR BULLETIN NO. 7597

ROSEMOUNT ENGINEERING COMPANY

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PRODUCT PREVIEW

REVERBERATION SYSTEMS for component testing



This series of high-intensity sound reverberation systems provides facilities for testing components under conditions of intense sound pressures, and for research in high intensity sound, and its effects. Since noise produced by aircraft and missiles affects not only personnel but also associated equipment, it is important that components be engineered to operate in such environments, says Stromberg-Carlson Electronics Center, Special Products Div., Dept. S/A, 1400 No. Goodman St., Rochester 3, N. Y.

Each system consists of a reverberation chamber, and a control console which also contains the audio power equipment to drive the sound sources. The reverberation chambers are available in 3 sizes ranging from 6x6x6 in up to 24x21x21 in but larger dimensions can be furnished on a custom basis.

Write in No. 427 on Reader Service Card

DC MOTOR is lightweight

The Model C-1360 dc motor is a lightweight, rectangular-type frame unit capable of producing .33 hp at 8400 rpm and .50 hp at 7700 rpm, and both ratings are for continuous-duty operation, says Hoover Electric Co., Dept. S/A, 2100 S. Stoner Ave., Los Angeles 25, Calif. The unit is adaptable to a wide range of aircraft, missile and industrial applications such as pumps, compressors, gear boxes, and actuators.

The motor features a brush holder design that permits even brush pressure, low radio noise interference, high reliability, and long life. It weighs five lbs, is 6.5 in. long, 2.875 in. wide, and 3.125 in. high. The same frame is used for .20 to one-hp motors with speed ranges to 30,000 rpm, and models are available for operation to 500 deg and at over a 200,000-ft altitude.

Write in No. 428 on Reader Service Card
more on page 286

LOOK
FOR THE
DIAMONDS—SIGN
OF FINISHING
QUALITY



Now, here's a fast, easy, economical way to almost double the protection against corrosion on your product. Simply follow up the IRIDITE process with a fast, easy application of IRILAC . . . and you've given your product extra protection for longer resistance to corrosive conditions, longer shelf or storage life protection from handling, and increased beauty for more attractive appearance and faster sales.

ON ALUMINUM

An IRIDITE-IRILAC finish will provide longer life for storm doors, windows, outdoor furniture, auto parts and accessories, tubing or wire goods. And, you have a choice of color finishes such as natural aluminum and golden yellow. Other colors may be obtained by an additional dye operation.

ON MAGNESIUM

IRILAC over an IRIDITE No. 15 finish increases corrosion protection, and provides resistance to finger printing and abrasion on all types of products, with color appearance ranging from light to dark brown.

ON ZINC

IRIDITE plus IRILAC gives your product longer life and brighter appearance. Color choices range from clear IRIDITE to olive drab, plus colored dye finishes.

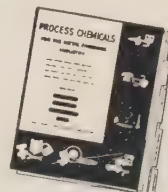
NOW—A Great New
Combination for
**DOUBLE
PROTECTION**
Against
Corrosive Conditions
on Aluminum,
Magnesium or Zinc

IRIDITE®
CHROMATE CONVERSION COATINGS
and
IRILAC™
CLEAR PROTECTIVE COATINGS

IRIDITE is the tradename for a specialized line of chromate conversion coatings that can be applied to any non-ferrous metal by brush, dip or spray methods—at room temperatures—manually or with automatic equipment. Upon application, a thin film forms which becomes an integral part of the metal itself, and thus cannot chip, flake or peel. No special equipment, exhaust systems or specially trained personnel are required.

IRILAC is the tradename for a line of clear protective coatings for all metals. As safe and easy to handle as water, they may be applied by brush, dip or spray methods. No exhaust or special fire protection equipment required. Adds protection and abrasion resistance to any base metal, plated part or parts treated with electrolytic or chemical post treatments, without chemical change.

For complete technical information on IRIDITE Chromate Conversion Coatings or IRILAC Clear Protective Coatings, write for **FREE TECHNICAL MANUAL**. Or, see the Allied Field Engineer in your area. He's listed under "Plating Supplies" in the yellow pages.



Allied Research Products, Inc.

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Chromate
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Plating
Brighteners

ARP®
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WAGNER
Line of
Equipment

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**THE
WESTINGHOUSE
SALES
ENGINEER
IS A
SHORTCUT TO**



**EXPERT
ENGINEERING
ASSISTANCE**



If you need engineering assistance in designing R&D test equipment, ground handling and support equipment, or ground power supplies—anything from design of a complete facility electrical system to the application of a single transistor—you *don't* have to wade through a complicated maze.

Contact your Westinghouse Sales Engineer.

He can summon a solid corps of expert engineering assistance for you. Often within hours. His phone call to the Aviation Facilities Group at Westinghouse headquarters will bring your problems to the immediate attention of skilled engineering talent. These engineers devote their time exclusively to solving aerospace industry problems.

These space-age specialists work with product design engineers in over 65 different Westinghouse facilities. They assure you positive, dollar-conscious solutions based on the use of modern concepts and equipment.

So, *don't* wade through a complicated maze. Save time. Save money. Call your nearby Westinghouse Sales Engineer. Discuss your problems with him today. Or write: Aviation Facilities, Westinghouse Electric Corporation, P.O. Box 868, Pittsburgh 30, Pennsylvania.

J-92500

**MEET SOME OF THE AIRCRAFT/MISSILE/SPACE SPECIALISTS
BACKING UP THE WESTINGHOUSE SALES ENGINEER:**



A. M. Bruning, Engineer-In-Charge,
Advanced Development Group
Age: 33
B.E., Johns Hopkins, 1949
M.S., Mathematics, University of
Pittsburgh, 1956
Specialties: Arc Heated Aero-
dynamic and Thermodynamic
Test Facilities, MHD Research
Facilities
Years with Westinghouse: 8



W. J. Walker, Engineer-In-Charge,
Aviation Facilities Group
Age: 42
B.S.M.E., University of Southern
California, 1949
Specialties: Wind Tunnels, Sonic
Fatigue Test Facilities,
Hardened Base Equipment,
Launchers
Years with Westinghouse: 11



R. A. Feranchak
Age: 29
B.S.E.E., Youngstown College, 1952
Specialties: Arc Heated Aero-
dynamic and Thermodynamic
Test Facilities, Explosive
Forming, Rotating Equipment
Test Stands
Years with Westinghouse: 7



R. F. Leepa
Age: 29
B.S.E.E., Lafayette College, 1953
Specialties: Military Power Plants,
Radar Antenna Drives
Years with Westinghouse: 6



P. J. Hawkshaw
Age: 36
B.S.E.E., Catholic University, 1950
Specialties: Continuous-Flow and
Hot Shot Wind Tunnels,
Explosive Forming
Years with Westinghouse: 9



J. McDonald
Age: 43
A.B., Chemistry, Engineering,
Physics, University of California,
1938
Specialties: Arc Chamber and
MHD Generator Development
Years with Westinghouse: 13



H. C. Lee
Age: 40
B.S.E.E., Chiao Tung University
(Shanghai), 1942
M.S., Engineering, Cornell
University, 1949
Ph.D., Cornell University, 1951
Specialties: Arc Chamber and
MHD Generator Development
Years with Westinghouse: 2



H. A. Zollinger
Age: 30
B.S.E.E., Michigan College of
Mining and Technology, 1951
M.S.E.E., University of Pittsburgh,
1958
Specialties: Drive Systems for
Loaders, Elevators, Erectors
and Launchers
Years with Westinghouse: 9

YOU CAN BE SURE...IF IT'S **Westinghouse**

Write in No. 363 on Reader Service Card at start of Product Preview Section

BRISTOL

chopper meets reliability standards of Army "Hawk"

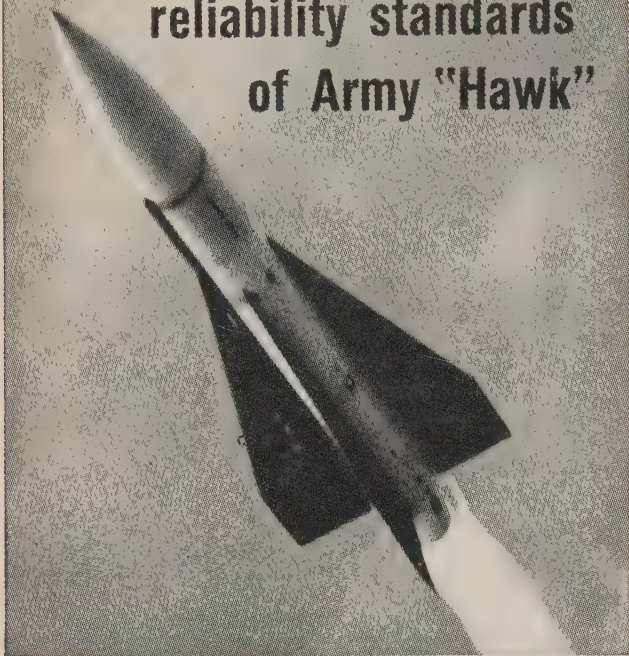


PHOTO COURTESY OF RAYTHEON COMPANY, WALTHAM, MASS.

Every part that goes into a modern-day missile system must pass a rigid battery of tests and a thorough statistical screening to insure highest possible reliability in action.

That's why we're pleased to announce that Bristol Syncroverter choppers play an important role in guidance of the U.S. Army HAWK missile, produced by Raytheon Company, Waltham, Mass., prime contractor for the complete HAWK weapons system.

Billions of operations. Bristol Syncroverter* choppers are ideal for applications requiring the utmost in statistical reliability. The Bristol life-test lab has now had miniature Syncroverter choppers running for years without failure—both with and without contact load. Just one sample: five choppers with 400-cycle drive and 12v, 1ma, resistive contact load have completed 26,000 hours (2.96 years) continuous operation—over 37-billion operations!

An extremely wide variety of standard models is available—including external coil low-noise types. For complete data, write: Aeronautical Components Division, The Bristol Company, 150 Bristol Road, Waterbury 20, Conn.

*T.M. REG. U.S. PAT. OFF.

9.26



actual size

BRISTOL

FINE PRECISION INSTRUMENTS
FOR OVER SEVENTY YEARS

See us in Booths 141-142 at the Southwest IRE Show

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PRODUCT PREVIEW

FREQUENCY METER provides direct reading

Model 504 Heterodyne Frequency Meter provides direct reading of frequency from 100 to over 10,000 mcps to an accuracy of 0.03 per cent. The meter is completely self-contained and covers all bands through the X-band without auxiliary equipment, says Polytechnic Research and Development Co., Inc., Dept. S/A, Brooklyn, N. Y.

The meter has an overall accuracy of 0.002 per cent at 5 mcps crystal clock points and 0.003 per cent or better over entire range. Resetability is 0.02 per cent or better. Input sensitivity at 50 mcps and above is -30 dbm and at 100 mcps is -5 dbm. The meter has a video amplifier bandwidth of 0.8 mcps.

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DECODER BEACON is high-power unit

The Model SRTS-2003CH S-band decoder-type guided missile beacon is a high-power, high-sensitivity unit designed to meet the requirements of radars using coders such as the KY-94/GPA. The rugged device contains decoder circuitry that accepts two- and three-pulse interrogation code groups and is capable of rejecting unwanted signals, says Telerad Mfg. Corp., Dept. S/A, 1440 Broadway, New York 18, N.Y.

Image rejection is 50 db minimum and triggering sensitivity, -65 dbm minimum. Both receiver and transmitter frequency are 2700 to 2900 mc, and peak transmitter power is 1000 W. Pulse width is 0.75 usec \pm 0.25 usec, and repetition rate is 100 to 1000 pps.

Write in No. 433 on Reader Service Card

more on page 288

FOR LEAK-DETECTION DEVICES



Infrared determination of nitrous oxide provides a safe, sensitive and flexible method of leak detection. This method is not affected by usual atmosphere components such as moisture, carbon dioxide and hydrocarbons. In addition, nitrous oxide will not harm pieces being tested and is more economical than other gaseous agents.


**OHIO NITROUS OXIDE: ODORLESS AND INERT • NONTOXIC
• NONCORROSIVE • NONFLAMMABLE • ECONOMICAL**

FREE TECHNICAL AID is available in the use of nitrous oxide for leak detection. For further information, please request the following bulletins:

- 1A Chemical, Physical and Pharmacological Properties of Nitrous Oxide with Results of Corrosion Tests
- 1B Gas Service Equipment for Nitrous Oxide Supply


Ohio Chemical

OHIO CHEMICAL & SURGICAL EQUIPMENT CO.

(A Division of Air Reduction Company, Incorporated) 
MADISON 10, WISCONSIN

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SPACE/AERONAUTICS



He has brainstorm ...to order

He's one of a group of AMF scientists who develop solutions to the utterly original problems of modern defense and human penetration of space. He doesn't build *better* mouse-traps. His business is completely new kinds of traps for mice that have never been caught.

Examples: A method of recovering potable water from human waste fluid, the major source of water in a sealed space vehicle... Methods of analyzing the effects of a nuclear blast on the earth's crust, how it changes the character of soil and rock, how its shock is propagated, what sort of building structure will withstand it... Platforms on which will be mounted primary standards calibration instruments for missile guidance systems. These platforms must be so vibration-free that natural earth movements must be compensated for. Platform vibrations are limited to millionths of an inch... A method of predicting temperatures in missile nose cones upon re-entry.

Single Command Concept

These samples of creative ingenuity reflect the resourcefulness AMF brings to any assignment.

AMF people are organized in a *single operational unit* offering a wide range of engineering and production capabilities. Its purpose: to accept assignments at any stage from concept through development, production, and service training... and to complete them faster...in

- Ground Support Equipment
- Weapon Systems
- Undersea Warfare
- Radar
- Automatic Handling & Processing
- Range Instrumentation
- Space Environment Equipment
- Nuclear Research & Development

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AMF Building, 261 Madison Avenue,
New York 16, N. Y.



engineering and manufacturing AMF has ingenuity you can use...

AMERICAN MACHINE & FOUNDRY COMPANY

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Well...not really in bottles. But, now you can get Super-Strength LEFKOWELD 2-Component Paste Type Adhesives in handy, disposable, high-grade polyethylene kits*. LEFKOWELD is accurately *pre-proportioned* for you. Clean, safe, convenient blending of adhesive and activator. Your hands are safe from irritating chemicals. Just a few simple steps and LEFKOWELD is ready to apply. Newest! Safest! Fastest! and Easiest! way to apply adhesives...the LEFKOWELD Adhesive Kit.

SUPER-STRENGTH LEFKOWELD ADHESIVES

Up to 4500 psi
tensile shear strength

Bond rigid or semi-rigid,
like or unlike materials

Resistant to oil, moisture,
gasoline, hydraulic fluid

Stable under widely
varying temperatures



Write today

*Semco "Semkits"
Patent No. 2,838,210
Semco Research, Inc.

Lefkoweld formulations are ideal for assembly, maintenance and repair. Technical data and recommendations on request.

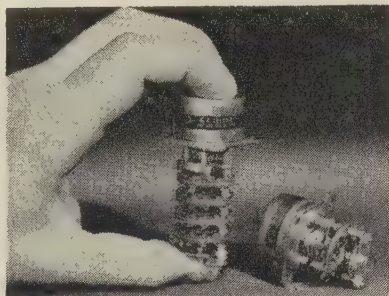
LEFFINGWELL
CHEMICAL COMPANY

P.O. Box 1187, Perry Annex, Whittier, Calif.

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288

PRODUCT PREVIEW

ROTARY SWITCH is miniaturized



Model Ledex BD2E circuit selector is reputed to be the smallest and lightest rotary switch now available. This sub-miniature assembly weighs less than 3 oz and measures only 1.5 in long and 1.375 in in diam, says G. H. Leland, Inc., Dept. S/A, 123 Webster St., Dayton 2, Ohio.

A low-cost unit with built-in ability to meet the most severe environmental conditions it can be either self-stepped or externally impulsed.

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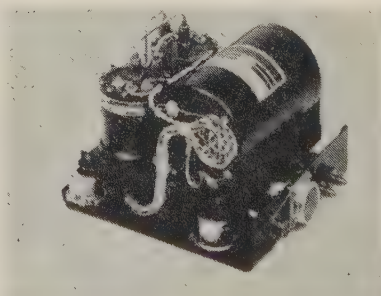
MILLIVOLTMETERS are chopper-stabilized

The meters accurately measure dc voltages from 0.0005 to 300 V from 60 to 400 cps. Two feedback loops achieve utmost operational stability of this instrument and make it largely independent of voltage variations, says Metronix, Inc., Dept. S/A, Chesterland, Ohio.

For applications where control as well as indication is required, the instrument is available with a meter-relay instead of the standard meter.

Write in No. 435 on Reader Service Card

TAS COMPUTER is miniaturized



The miniaturized true airspeed computer system is rugged, highly accurate, and is less than one-half the size of the unit it replaces. It is lightweight, occupies 300 cu in and will withstand extreme shock and vibration without the use of shock mounts or isolations, says Gianini Controls Corporation, Dept. S/A, 911 E. Green Street, Pasadena, Calif.

Components include two standard pressure transducers, one temperature probe, and a single servo computer.

Write in No. 436 on Reader Service Card
more on page 290

better
holding

+
easier
release

+
highest
quality

=greater reliability

LOCKWELL* quick release pins

Exclusive design features in this Hartwell development make these Lockwell Pins superior for *your* application.

Lockwell Pins are built with an exclusive 4-ball locking element for superior tension properties... with fail-safe design assuring permanent operation... with handles that provide greatest non-slip clearance... and with RED release button for quick identification.

SPECIAL DESIGN—In addition to standard configurations, Lockwell features can be incorporated into pins to meet special design requirements. Your inquiry is sincerely invited.

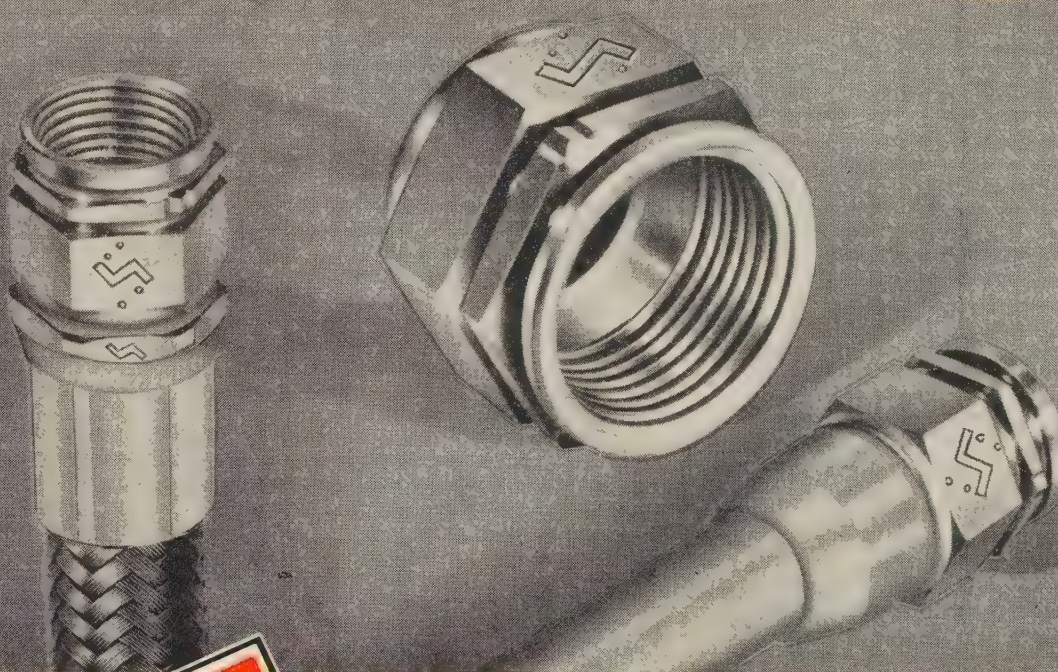


*TRADE MARK



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SPACE/AERONAUTICS

**NOW! POSITIVE LOCKING WITHOUT
THE LIMITATIONS OF WIRING DEVICES**



NEW **STRATOLOK**

REG. APPLIED FOR

SELF-LOCKING FLUID COUPLING NUT

Eliminate time and expense involved in safety wiring. The new Stratolok* self-locking fluid coupling nut assures positive locking and trouble-free sealed joints in critical applications.

Stratoflex's new Stratolok series of self-locking nuts is based on a 3-way mechanical displacement of threads. The Stratolok locking element permits free hand starting and insures that the lock is fully engaged before the nut is completely

seated. When fully seated, the lock is retained.

Stratolok nuts meet all locking performance requirements of Specification MIL-N-25027. They are available in a complete range of sizes and are reusable and completely interchangeable with existing AN and MS nuts. Stratolok "S" series nuts, for temperatures up to 550°F, are Cadmium-plated steel; "CR" Series, for temperatures up to 800°F, are silver-plated stainless steel.

For complete information, write for Stratolok Bulletin S-8.

*Formerly SPS Self-Locking Nut

STRATOFLEX

Inc.

P.O. Box 10398 Fort Worth, Texas
Branch Plants: Hawthorne, Cal., Fort Wayne, Toronto
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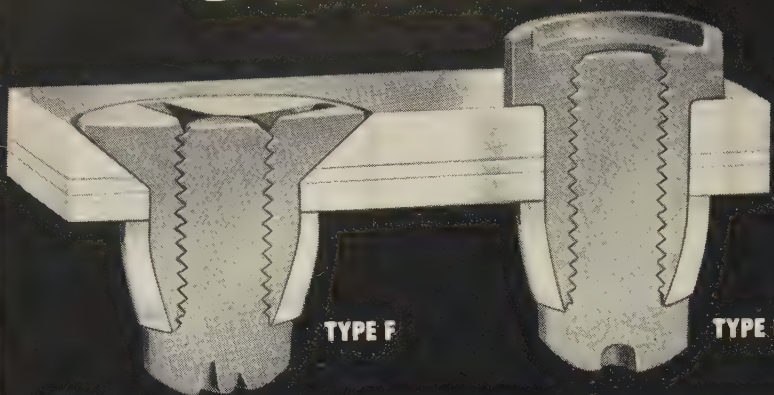
SALES OFFICES:

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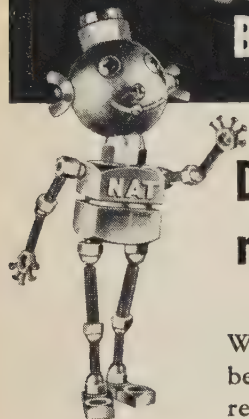
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JO-BOLT®



BLIND LOCKING FASTENERS*

* Patented



DO IT BETTER • DO IT FASTER in missile/aircraft frame assembly

What happens in JO-BOLT Fastener installations can be seen at a glance, in the cross section above. The resulting clamp-up of sheets and structural members is tight and positive, 100% effective.

That's highly important... but not even the half of it. First, consider this... JO-BOLTS® are high-strength structural fasteners, typically providing: shear strength of 95,000 psi min. in steel types; 85% AN Bolt tensile strength in #10 and 1/4" diameters; vibration resistance superior to bolts with lock nuts.

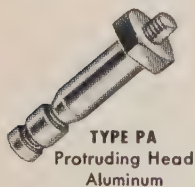
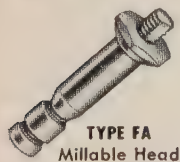
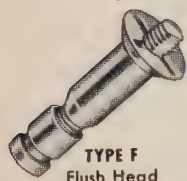
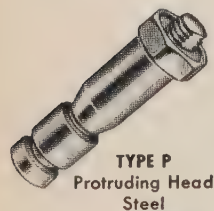
Second, JO-BOLT Fasteners are lightweight and compact, allow savings in fastener weights averaging 50% or higher, often permit use of narrower and lighter substructures.

Third, JO-BOLT Fasteners can always be installed by one man from one side of the work... eliminating most common access and clearance problems.

Finally, JO-BOLT Fasteners are foolproof and fast, can be popped into holes prepared and aligned for them, and driven to grip inside of seconds, always resulting in high-quality work, uniform and unmarred, regardless of worker skill.

They are so good, in fact, at fastening better and faster that they've been preferred and specified in practically all high-performance aircraft ever since introduction.

Write for illustrated booklet J 59. It lists specifications for all types, tells about A 286 Hi-Temp and other special JO-BOLT Fasteners.



THE NATIONAL SCREW & MFG. COMPANY

CLEVELAND 4, OHIO

California Division, Los Angeles 22

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PRODUCT PREVIEW

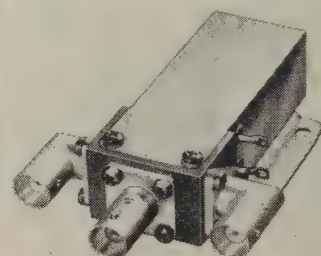
RF SIGNAL SOURCE for microwave application

Series 700 RF signal sources are available for CW pulse or dual codes of operation. Each unit features built-in RF power monitors, filament regulators, band switching, generator tube protective circuits, vacuum or semi-conductor power supplies, personnel/circuit protection and complete control function indicators, says Burmac Electronics Co., Inc., Dept. S/A, Rockville Centre, N.Y.

The series incorporates optimum wave shape and circuit parameters to insure proper operation of the generators tube and are available from the ultra-high frequency through the K-band microwave spectrum.

Write in No. 437 on Reader Service Card

COAXIAL CHOPPERS are insensitive to shock



This line of coaxial choppers incorporates a unique patented center-pivot reed construction for dynamic cancellation of external effects of shock and vibration. The units may be used for continuous or asynchronous switching of coaxial signals, says James Vibrapower Co., Dept. S/A, 4050 N. Rockwell St., Chicago 18, Ill.

The driving frequency can be dc to 175 cps switching frequency can be dc to 500 Mcps.

Write in No. 438 on Reader Service Card

TELEMETERING TRANSMITTER is extremely rugged

Model TR-10 is a true FM telemetering transmitter, in which frequency is modulated in accordance with the intelligence transmitted. All low-level and frequency determining stages are transistorized to eliminate incidental FM noise produced by vibrating tube elements, says United Electro-dynamics, Dept. S/A, 200 Allendale Rd., Pasadena, Calif.

The unit is hermetically sealed for operation at all altitudes, and exceeds MIL specifications for salt spray and other missile environments. Power output is 2.5 w in the 215-260 Mc telemetering band, and the carrier frequency is crystal stabilized. The unit weighs less than 17 oz and measures 4.25 x 2.87 x 1.53 in.

Write in No. 439 on Reader Service Card
more on page 292

SPACE/AERONAUTICS



| *Now in magnesium and aluminum*

FOUR DOW PLANTS OFFER AIRCRAFT AND MISSILE MEN WIDE CHOICE OF MAGNESIUM WARES

Coiled sheet, thin wall castings, many other production items are now available from Dow's big rolling mill, foundry and fabrication facilities.

Aircraft and missiles manufacturers on the alert for improved materials and production methods would enjoy a personal tour of the four Dow plants that turn out magnesium products. Next best thing is this quick rundown on the new ways of forming and fabricating magnesium now being practiced in these plants to open up new uses for the lightweight metal...



TOOLING PLATE, extra flat, is annealed to eliminate residual stresses.

At the huge Madison, Illinois, rolling mill, for example, they're making magnesium sheet that doesn't require stress relief after welding. This is a major step forward in light metal technology and a boon to manufacturers using magnesium assemblies. Madison has also increased the maximum width of sheet to six feet. Five different sheet alloys, including elevated temperature alloys, are now available either flat or in coils.

To keep abreast of the rapidly increasing demand for precision

jigs and fixtures, Madison keeps a close watch on the tolerances of Dow magnesium tooling plate. Typical flatness tolerances, for example, are 0.010 inches in any six feet. This means greater accuracy and less machining for users of Dow tooling plate. Madison is now turning out both magnesium and aluminum extrusions that cover a wide range of sizes: from delicate precision parts to a 30-inch circumscribed circle size—made by Madison's mammoth 13,200 ton extrusion press.

Over in Bay City, Michigan, interesting things are happening, too. At the well-equipped Dow magnesium foundry, largest in the U. S., sand and permanent mold castings of all sizes and shapes are being produced on a volume basis. Complete facilities are maintained for heat treatment, styrene DMI impregnation and chemical treatment. A well-staffed quality control team makes sure that all specifications are met or exceeded, and that the most modern equipment and techniques are fully utilized.

The Bay City foundry casts many complex and difficult designs. Large castings with walls as thin

as 0.100 are now being produced. Other useful developments include cast-in tubeless passageways for use as hydraulic lines, special coring techniques for casting enclosed shapes, and new magnesium casting alloys.

A new die casting plant is now on stream at Bay City. This facility houses the most advanced magnesium die casting equipment, including cold chamber metering units which automatically feed metal to the machines and contribute to unusually high production rates. To assure close alloy composition control on both die casting plant and foundry, a direct reading spectrometer provides frequent and precise analyses of the molten metal. Similarly, X-ray equipment is also available where radiography is needed in quality control.

The Dow fabrication plant, also in Bay City, offers capacity for volume work on magnesium assemblies. Here, too, developmental work on magnesium is constantly in progress. The plant is set up to handle large or small jobs, and plenty of both. Its activities include deep drawing, bending, spinning, stamping, piercing, machining, arc and spot welding, assembly, chemical treatment and painting. This plant has pioneered many "firsts" in magnesium production, such as hot drawing, spot welding and automatic welding.



DOW FOUNDRY offers production capacity for sand and permanent mold castings of all sizes.

For more information about Dow's magnesium production facilities, contact the nearest Dow sales office or THE DOW METAL PRODUCTS COMPANY, Midland, Michigan. Merchandising Department **1000EW4**.

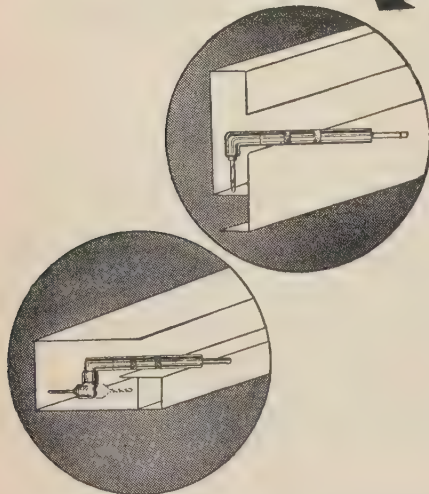


THE DOW METAL PRODUCTS COMPANY

Division of The Dow Chemical Company

Write in No. 370 on Reader Service Card at start of Product Preview Section

... FOR THESE ANGLE
DRILLING APPLICATIONS



● AND MANY MORE... there is a
TERRY Angle or Flexible Tool to fill
your needs.

Angle Drilling **TERRY** Attachments

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GEORGE A. TERRY CO.

354 S. Elmwood Ave., Buffalo 1, N. Y.

Write in No. 371 on Reader Service Card

WAVEGUIDE SWITCH is rugged, lightweight



A new Delta micro-miniature K-band waveguide switch that weighs 6½ oz has been developed by Don-Lan Electronics, Inc., Dept. S/A, Santa Monica, Calif. The device and the original Delta X-band switch are available in 26 V dc and 115 V ac, 400 cycle.

Applications for the design have included airborne guidance and control equipments, VHF relay stations, and general communications equipment. The K-band unit, W-6KS, has an RF power rating equal to the associated waveguide, and RF switching power is attained with a maximum VSWR of 2.1/1.0 during the switching cycle, and 1.2/1.0 maxi-

mum in either position over the entire frequency range. Features include ruggedness, remote control to switch a single input to either of two outputs, a .007-sec switching time, and minimum isolation of 40 db down.

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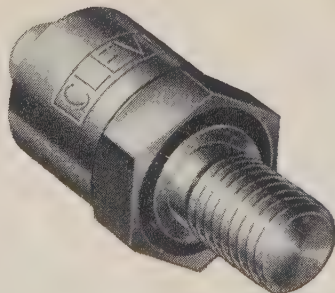
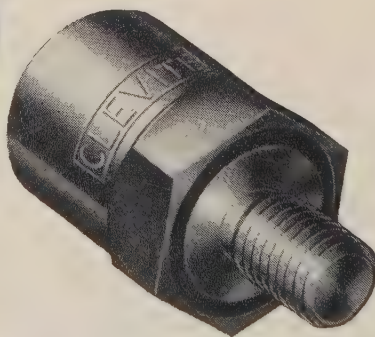
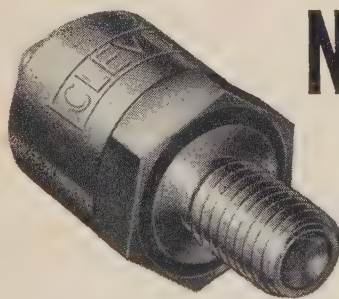
TUBE has long storage time

Transient events detected by radar, television and oscilloscopes, or produced by computers, can be held for hours by this one-in storage tube, says Allen B. Du Mont Laboratories, Inc., Dept. S/A, 750 Bloomfield Ave., Clifton, N. J. The long storage time derives from a "charge-control" approach for storage rather than the "charge-loss" technique.

The Storatron-type storage device does not present data on a screen of its own but allows it to be continually viewed remotely on all TV tubes or conventional KRT displays. This feature makes possible application to missile reconnaissance or defense centers. The electrical read-in, read-out type storage tube has a writing rate of 300,000 ips. Information can be written in at one rate and readout at another. Tube resolution is at least 500 lines.

Write in No. 441 on Reader Service Card
more on page 296

New Clevite Accelerometers!



500°F Operation

3% Lateral Sensitivity

50kc 1st Resonance

1600 mmfd. Internal Capacity

Stock Sizes: 5 mv/g

10 mv/g, 20 mv/g

Bulletin 9503 has the details.
Write for it today.

CLEVITE ELECTRONIC COMPONENTS

DIVISION OF



3402 West Century Boulevard
Inglewood 2, California

3405 Perkins Avenue
Cleveland 14, Ohio

FIELD OFFICES

1915 North Harlem Avenue
Chicago 35, Illinois

60 Franklin Street
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Write in No. 372 on Reader Service Card at start of Product Preview Section

SPACE/AERONAUTICS

MEETS EVERY TEST...

BEFORE AND AFTER COUNTDOWN

Acme-Newport Steel

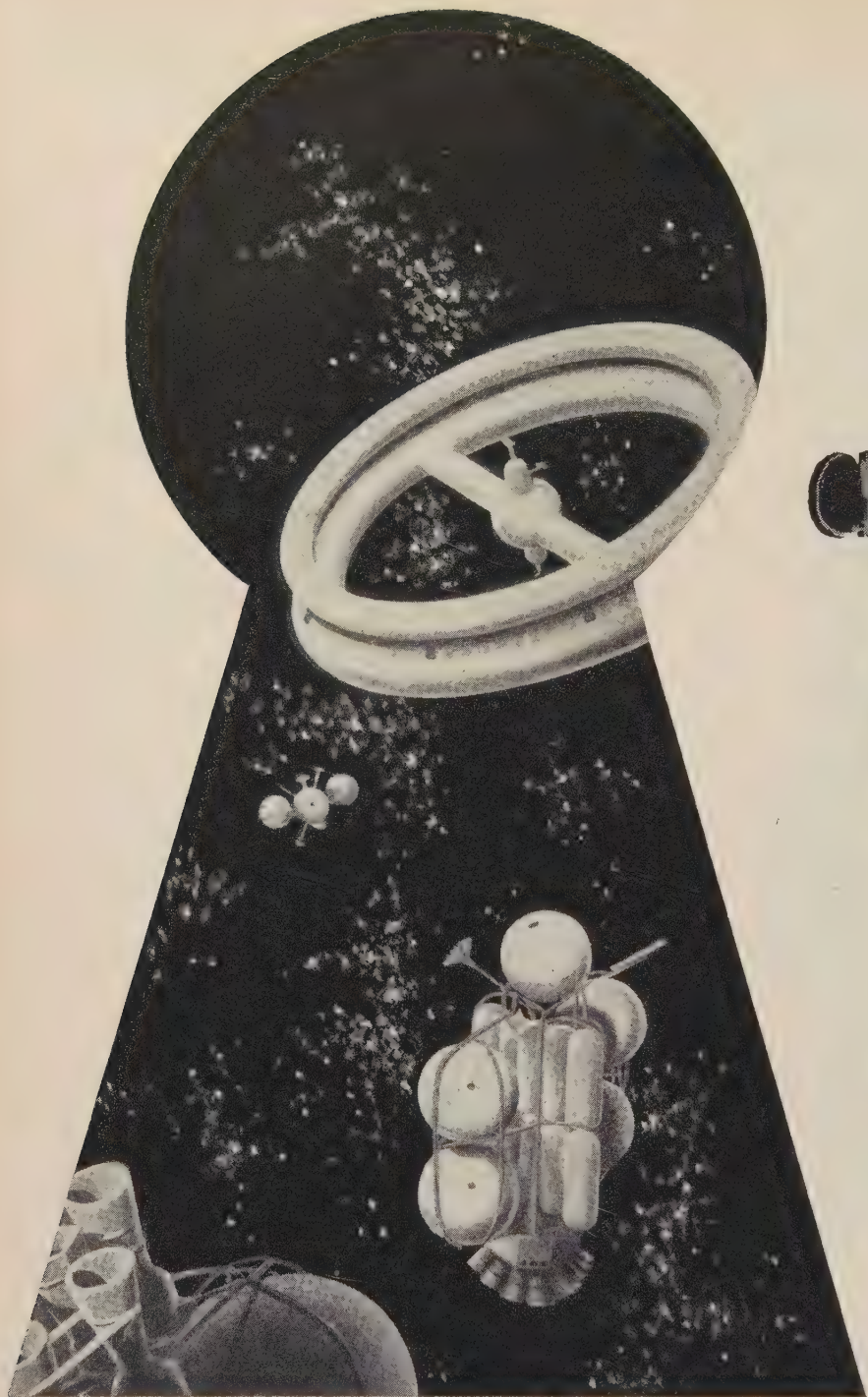


Prim and subcontractors here find dependable uniformity in aircraft quality alloy and carbon grades of plate, sheet and strip. Continuous control ensures unfailing adherence to every specification for component parts in rockets, missiles, planes and ground support equipment. Facilities are modern; methods are the latest; and over 20% of our employees wear the coveted 25-year service pin symbolic of their steelmaking skill. High standards maintained in defense production are duplicated for industry generally. So whatever your needs, contact Acme-Newport before you order again.

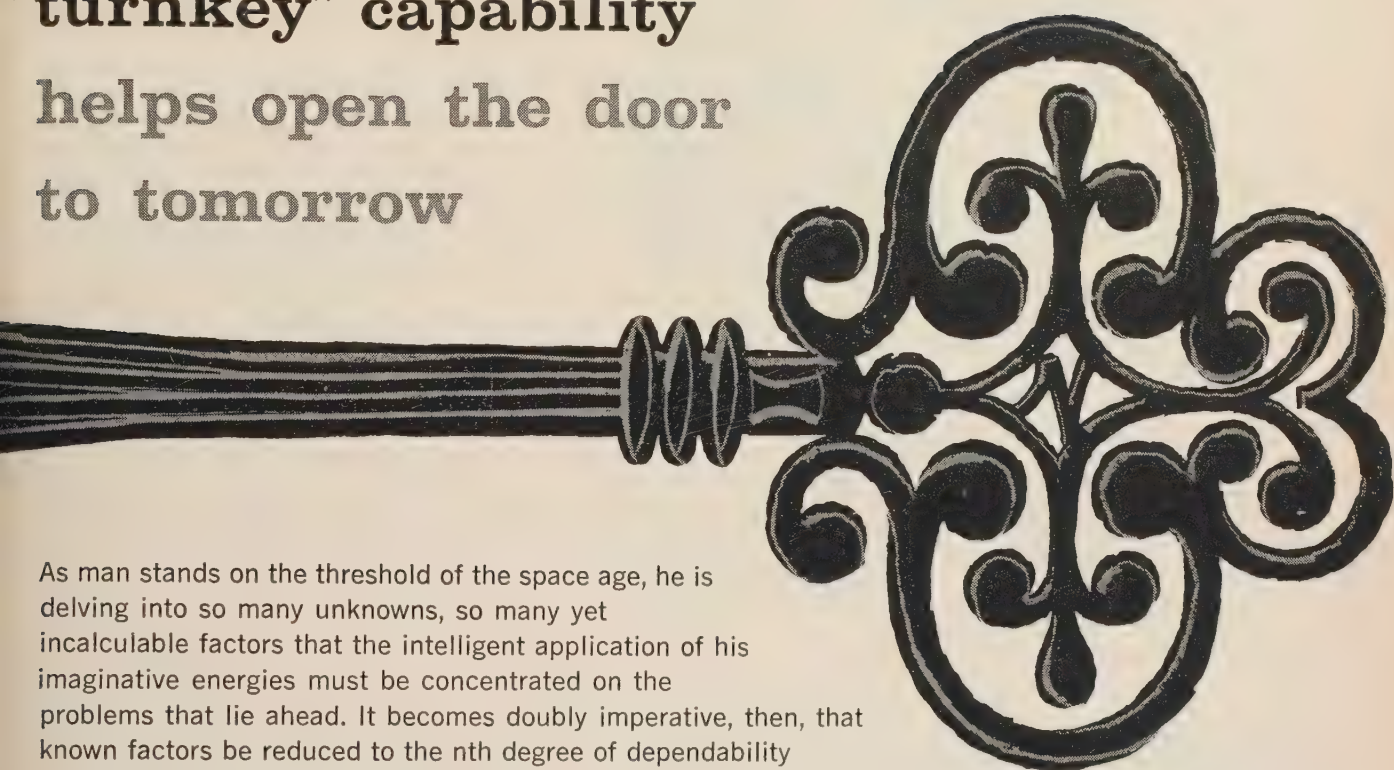
Acme-Newport Steel
COMPANY
NEWPORT, KENTUCKY

A SUBSIDIARY OF  COMPANY

Write in No. 373 on Reader Service Card at start of Product Preview Section



North Electric's "turnkey" capability helps open the door to tomorrow



As man stands on the threshold of the space age, he is delving into so many unknowns, so many yet incalculable factors that the intelligent application of his imaginative energies must be concentrated on the problems that lie ahead. It becomes doubly imperative, then, that known factors be reduced to the nth degree of dependability to free his energies for the new tasks that lie beyond the known.

North Electric has already been an invaluable partner in the first exploratory steps toward full realization of man's venture into space.

North Electric's experience in the field of ground environmental support control and communications, testing, missile check-out and similar supporting work has developed at North full "turnkey" operational and management capabilities as already applied in control and communications switching centrals for BMEWS and AIRCOM, in fixed and mobile channel control centers for Morocco—Spain—U. K. Tropospheric-Scatter complex and ground communications equipment for the

THOR and JUPITER projects.

From design and development through engineering and manufacture to installation, training and operation, North can bring to you the experience, technical and professional integrity, and system management talents that have made "dependability" and "North" synonymous in these fields.

North's unique capabilities in the fields of control and communications stem from the wealth of experience and genuine talent embodied in an engineering group whose entire professional environment lies in the application of system concepts to problems such as may be facing you right now. To learn how North can help you today, write Dept. SA-1.

ELECTRONETICS DIVISION

NORTH ELECTRIC COMPANY

Galion, Ohio



Write in No. 374 on Reader Service Card at start of Product Preview Section

Here's
data
on the
New

DIAL HEAD AGASTAT® time/delay/relays

These relays have recently been re-designed—improved in performance and appearance. So you'll want up-to-date specs.

This free folder gives complete details on all models. In it you'll find operating specs, timing ranges, contact capacities, dimensions, diagrams of contact and terminal arrangements, and data on mounting and installation accessories.

For your copy, write: Dept. A34-419.



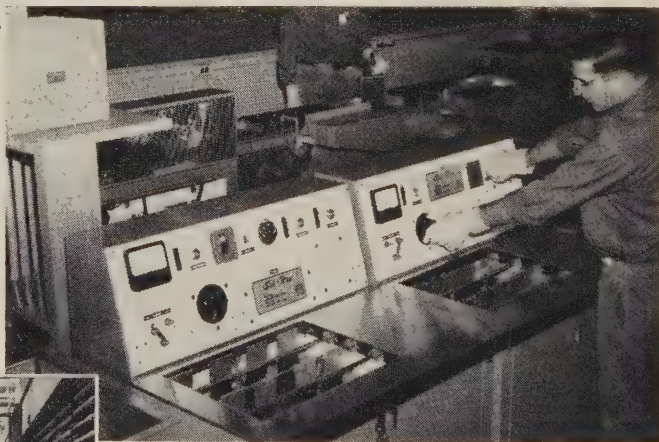
ELASTIC STOP NUT CORPORATION OF AMERICA

Elizabeth, New Jersey

Write in No. 375 on Reader Service Card at start of Product Preview Section

These JET PLATERS are used to gold-plate some of the printed wiring boards for the SAGE Computer — as well as for experimental IBM equipment currently under development.

Heart of our SAGE System is the 275 ton IBM Computer. Shown here are some of the computer frames containing pluggable electronic units which perform data processing to solve air-defense problems.



IBM SAGE COMPUTER CIRCUITRY PLATED WITH SEL-REX BRIGHT GOLD

The 275 ton computer pictured, in part, above has 7,300 pluggable units containing printed card assemblies. To help maintain the "built in" reliability for which IBM is famous the world over, these assemblies were plated with Sel-Rex Bright Gold Process. The precision-plating required by this application was done in four JET PLATERS—complete precious metal plating facilities in a single compact cabinet.

When the unique metallurgical properties of a precious metal are required—without the shortcomings of conventional electroplate—leading missile, electronic manufacturers and Government Agencies specify SEL-REX. Learn why from our latest catalog #EL-1, FREE on request.



SEL-REX CORPORATION

NUTLEY 10, NEW JERSEY

Write in No. 376 on Reader Service Card at start of Product Preview Section

PRODUCT PREVIEW

CRIMPING TOOL has safety feature

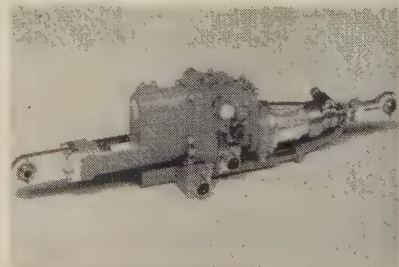


This high-speed pneumatic tool for wire sizes An No. 18 or smaller provides a crimp that is stronger than the wire, says The Deutsch Co., Dept. S/A, Municipal Airport, Banning, Calif. The crimping tool, which handles both pins and sockets in the Deutsch DS Series minatures, can be used in either hand or bench operation.

The device has a safety feature that prevents crimping action in case of air failure or intermittent pressure. Contacts are fed in from a plastic cartridge that snaps into the tool. Two triggers are used, one to position the contact and the other to complete the crimp.

Write in No. 442 on Reader Service Card

SERVOACTUATOR has mechanical feedback



A simplified configuration for improved performance and reliability is being used in a new line of electrohydraulic servoactuators featuring mechanical feedback, says MOOG Servocontrols, Inc., Dept. S/A, East Aurora, N. Y. With this feedback arrangement, the actuator is positioned proportional to the dc input current.

The feedback design eliminates the conventional electrical feedback transducer and associated amplifier used to close the servo loop. The wide range of models available include those with piston areas to three sq in and strokes to four in, open-loop gains up to 120 sec⁻¹ can be obtained. The lightweight device, suitable for missile and spacecraft controls, permits integral inclusion of components such as telemetry potentiometers, velocity limiters, and shut-off solenoid valves.

Write in No. 443 on Reader Service Card
more on page 300

SPACE/AERONAUTICS

SAGINAW ball/bearing SCREW

A rugged Saginaw Ball Bearing Screw is used to raise and lower the new "Jetway" passenger loading corridor, manufactured by P I Steel Corporation in Los Angeles. It's now in operation for United Air Lines at San Francisco and New York's Idlewild Airport. These movable, telescoping corridors directly connect terminal and aircraft. Travelers pass through, protected from wind, rain, fumes and noise.

The Saginaw b/b Screw used here is a standard rolled thread assembly with a B.C.D. of three inches and measuring seven feet in length. The Saginaw Screw is in a motor-driven shaft under the outboard section of the "Jetway" . . . and in seconds, smoothly and accurately matches the floor elevation of the huge corridor to that of the plane.

Airlines specifically avoided hydraulic elevating systems—the Saginaw b/b Screw was selected because it converts *rotary* motion into *linear* motion with *over 90% efficiency*, plus contributing important savings in maintenance and power and providing noise-free operation. The Saginaw b/b Screw may bring these and other profitable benefits to *your* product, too. Details are yours by phoning or writing Saginaw Steering Gear Division, General Motors Corporation, Saginaw, Michigan—*world's largest producers of b/b screws and splines.*

Lifts giant "TRAVELING" corridor



Actuation To Fit Your Individual Requirements

Have been built as small as $\frac{3}{16}$ in. B.C.D. and 1 $\frac{1}{2}$ in. long, as large as 6 in. B.C.D. and 40 ft. long. Larger sizes can be built to your order.

Saginaw

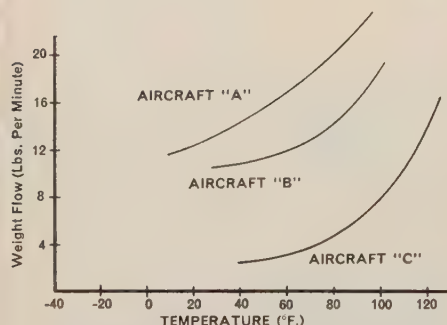
ball
bearing
Screw

WORLD'S MOST EFFICIENT ACTUATION DEVICE

VAP-AIR cooling effect detector

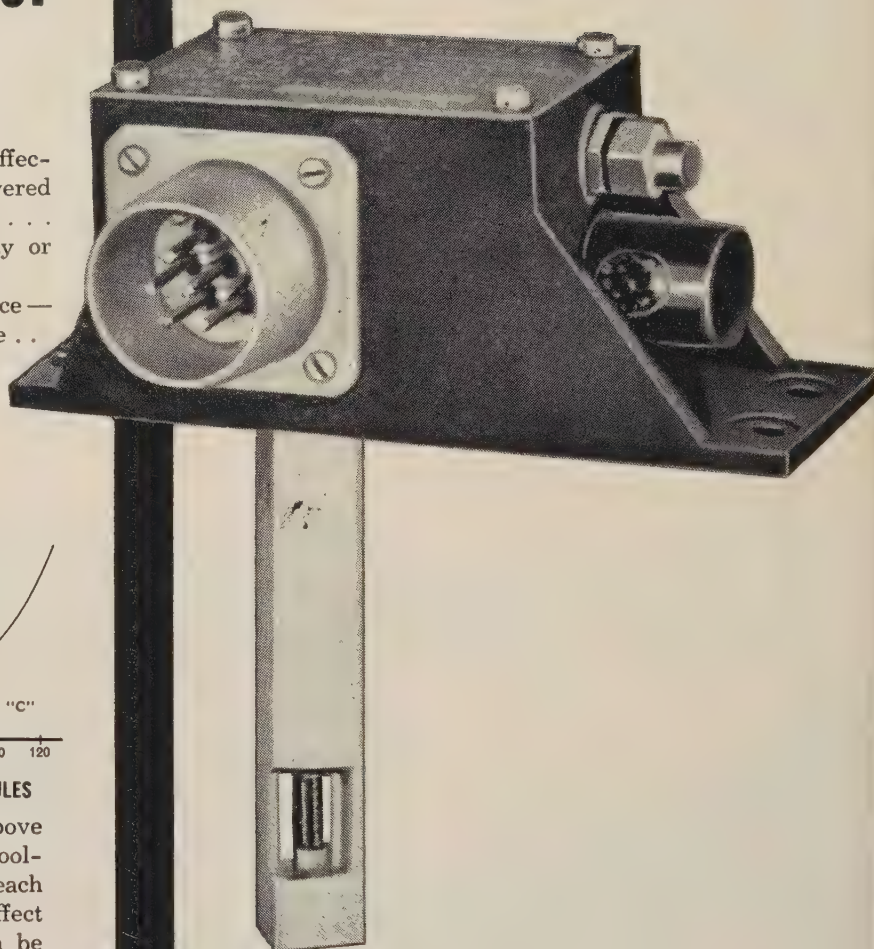
Senses the actual cooling effectiveness of the air being delivered over electronic components . . . regardless of volume, density or temperature delivered.

A unique and proven device — lightweight, positive, accurate . . . under all conditions.



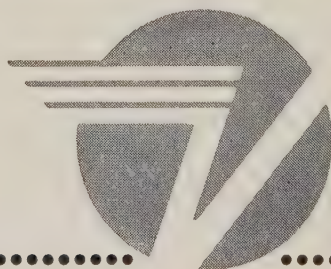
COOLING EFFECT DETECTOR SCHEDULES

Area of adequate cooling lies above each curve. Area of deficient cooling lies below and to right of each curve. Since the Cooling Effect Detector is adjustable, it can be matched to each curve.



VAP-AIR — SPECIALISTS IN AIRCRAFT TEMPERATURE CONTROLS FOR NEARLY 20 YEARS

Entire systems and a complete line of sensors, electronic controls and precise voltage regulation, electropneumatic and electromechanical valves, advanced in-line valves and regulators, electric power controllers and heat exchange equipment — for aircraft, missiles and ground support.



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Please send me complete information on the Vap-Air
Adjustable Cooling Effect Detector.

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Write in No. 377 on Reader Service Card at start of Product Preview Section

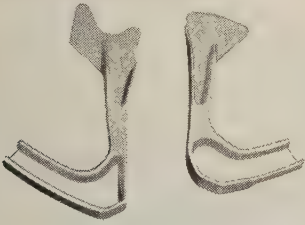
SPACE/AERONAUTICS

These no-draft Alcoa Forgings for F-104 save Lockheed 40 cents on the dollar



DORSAL FORMER

Precision forged by Alcoa to finished dimensions—with zero draft.



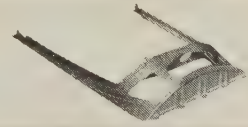
AIRSCOOP FITTINGS

Alcoa no-draft forgings with contours forged to various angles.

Take a close look at the *Dorsal Former* at left. Notice the thin, upstanding ribs. Alcoa forged this part to finished dimensions, *with no inside taper to machine off.*

Alcoa supplies Lockheed with many close-tolerance, untapered rib forgings. The *Airscoop Fittings* are sophisticated examples. In all, the F-104 carries 60 no-draft forgings. Lockheed estimates the average saving over conventional machined parts comes to 40 cents on the dollar.

Let us show you what we can do with aluminum in any form—plate, casting, forging, extrusion, impact. Call any Alcoa sales office, or write Aluminum Company of America, 2027-D Alcoa Building, Pittsburgh 19, Pa.



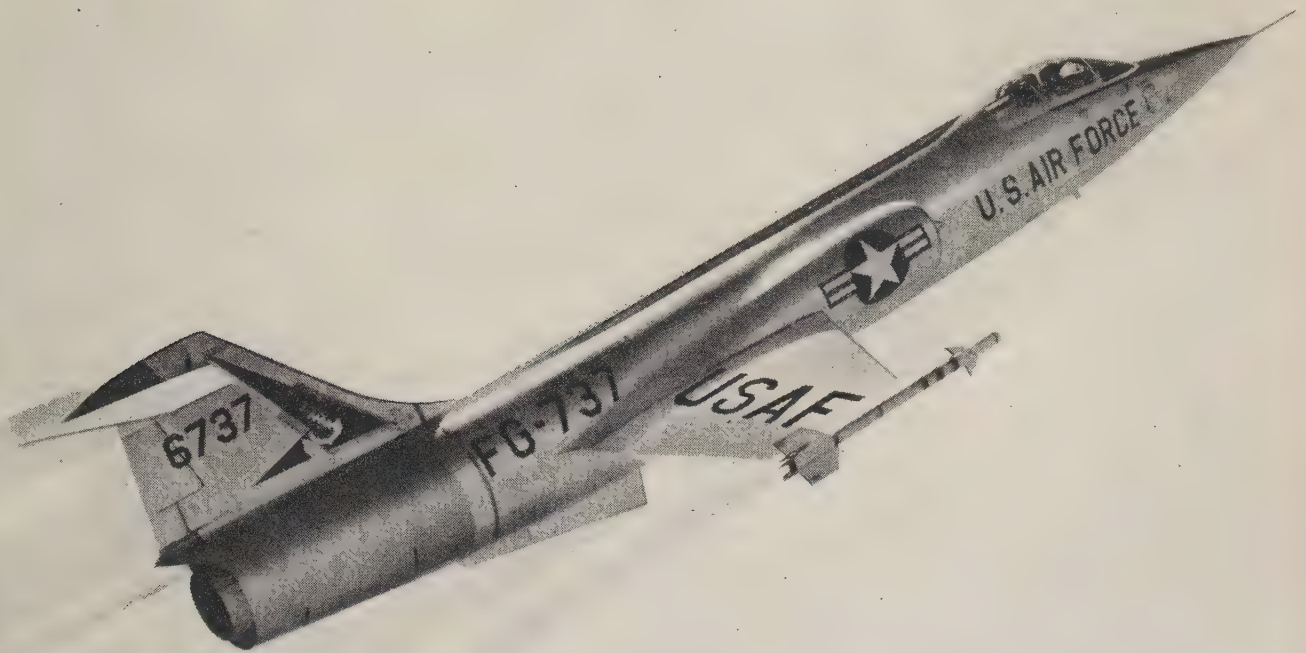
WINDSHIELD FRAME

We mention the *Windshield Frame* above to point out our capabilities in other directions. This part measures 38 x 30 x 6 in. Wall thickness is 0.110 in. for 80 per cent of the casting area. This requires several sand and plaster cores which have to assemble and hold dimensions within ± 0.03 in. across the joints. Casting must conform to fuselage contour within 0.015 in. To top it off, defects considerably smaller than a pinhead are cause for rejection.



*Your Guide
to the Best
in Aluminum
Value*

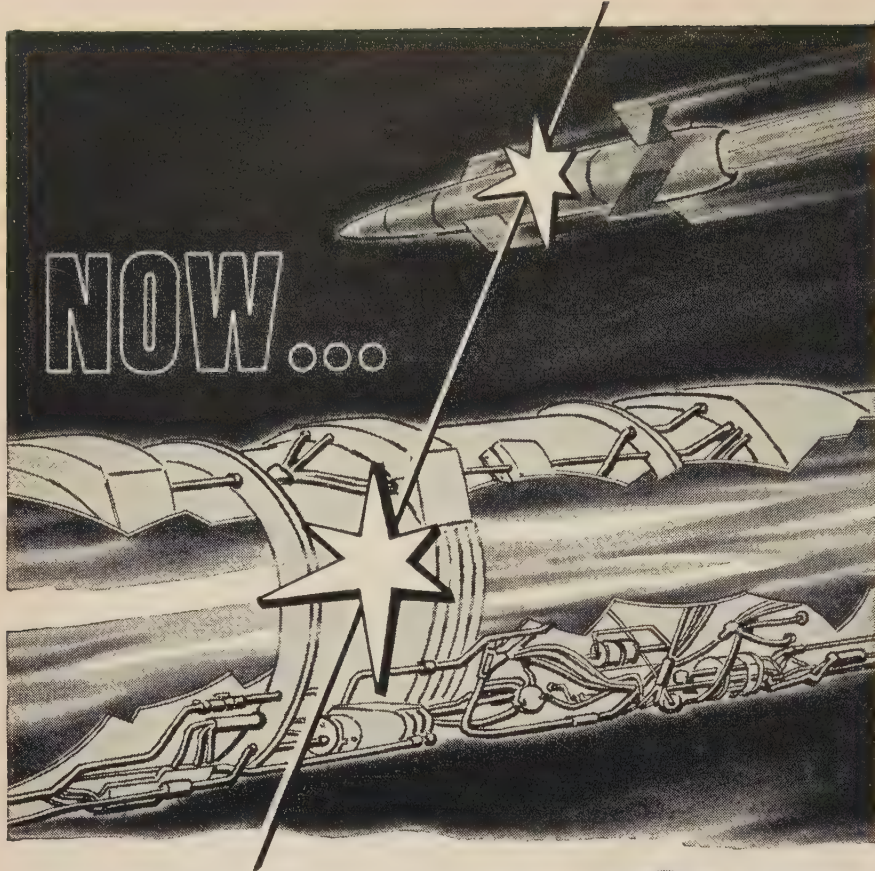
For exciting drama watch "Alcoa Presents" every Tuesday, ABC-TV, and "Alcoa Theatre" alternate Mondays, NBC-TV



LOCKHEED'S F-104 STARFIGHTER

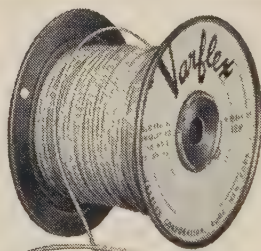
Winner of the Collier Trophy for 1959. Currently holds world's altitude record of 103,395 feet and all eight time-to-climb records. First airplane ever to hold world's altitude, speed and time-to-climb records simultaneously.

Write in No. 378 on Reader Service Card at start of Product Preview Section



a silicone resin sleeving so flexible you can get it in spools or coils!

- **FLEXIBLE** — may be manipulated at all temperatures, -70° to $+500^{\circ}$ F. without cracking or checking. Dielectric strength remains even when sleeving is knotted.
- **HIGH DIELECTRIC STRENGTH** — up to 7000 Volts, depending on grade. Certified to meet government specification MIL-I-3190, latest revision.
- **RADIATION RESISTANT** — retains nonconductive properties under greater-than-average random intensities.
- **WIDE RANGE OF SIZES** — .010" I.D. to 3" I.D. Larger sizes possible.
- **COLOR CODED** — available in 12 brilliant, non-fading colors.
- **CHOICE OF LENGTHS** — for the first time, continuous lengths up to 5000 feet available, thus eliminating waste. 36 inch lengths where preferred.
- **DEPENDABLE, FAST DELIVERY** — Immediate delivery on standard items from stock . . . 48 hours for new production.



VARGLAS SILICONE RESIN "500" SLEEVE

Extremely useful where miniaturization increases heat and dielectric load on smaller wires, Varglas Silicone Resin "500" is only one of many sleeveings made by Varflex for this type of service. If you have a special insulating problem, call on our engineers for modifications of existing products, or for developmental work to meet stringent new requirements.

● Send for free test samples.

Varflex

SALES CO., INC.

"Never Satisfied Until You Are"

Manufacturers of Electrical Insulating Tubing and Sleeving • 316 N. Jay St., Rome, N.Y.
Write in No. 379 on Reader Service Card at start of Product Preview Section

PRODUCT PREVIEW

FREQUENCY STANDARD is stable 400-cycle source

Designed for precision airborne and missile applications the standard consists of three unijunction countdown stages, one binary divider stage and a tuned power output stage. Frequency accuracy at $+25^{\circ}$ deg C is $400,000 \pm 0.009$ cps under any of the following conditions in combination: $0-60^{\circ}$ deg C; 25 to 30vdc; 15 g's; 5-200cps. Vibration at $+25^{\circ}$ deg C; says Designers for Industry, Dept. S/A, 4241 Fulton Pky, Cleveland 9, Ohio.

Output power is 55 mw. Input voltage is 28 V d-c.

Write in No. 444 on Reader Service Card

TAPE RECORDER is miniature



An airborne tape recorder for missiles and satellites weighing only $10\frac{1}{2}$ oz, will register information on one to 16 channels on a continuous tape. It has high resistance to shock, over 2000g's and a low power consumption of $1\frac{1}{2}$ watts, says Leach Corp., Dept. S/A, Los Angeles, Calif.

The recorder occupies 14 cu in of space, and will have applications in military and commercial fields.

Write in No. 445 on Reader Service Card

ROCKET VALVES are explosive-actuated

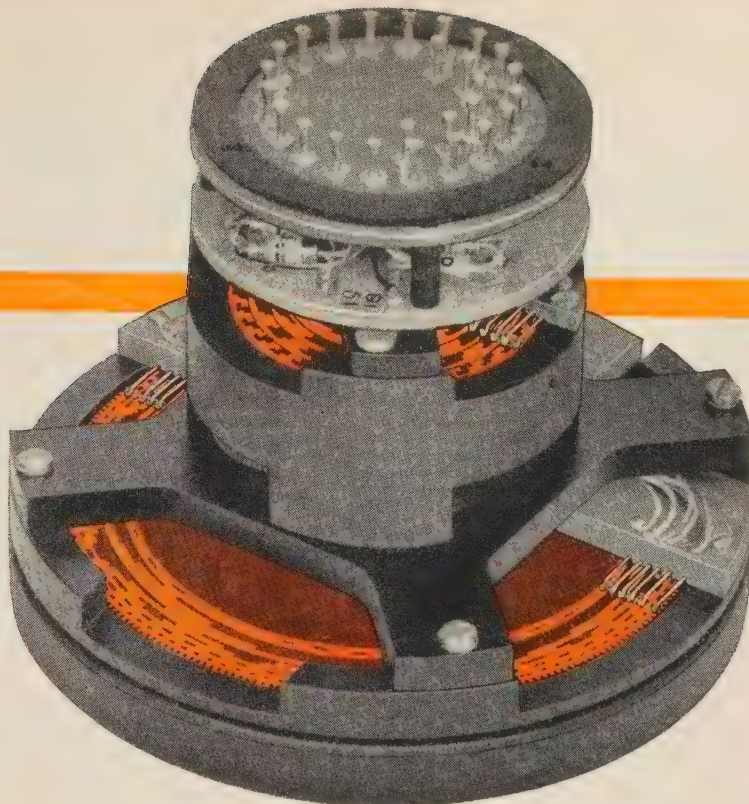
Both normally-open and normally-closed explosive-actuated valves are being made in $\frac{1}{8}$ to $2\frac{1}{2}$ -in. tube size by Pyronetics, Dept. S/A, 11973 E. Slauson, Santa Fe Springs, Calif. The lightweight units can be equipped with lead-wires or integral connectors, and AND-10050, MS-33656 or other fluid connections are available.

The normally-closed types in the line include the Model 1005, a tandem valve for a pre-packaged liquid propellant rocket engine. It simultaneously opens $\frac{1}{4}$ -in. id RFNA and UDMH lines. Two other units, both $\frac{1}{4}$ -in. and normally-closed valves, are: the Model 1008, which releases 3000 psi gas to pressurize propellants in a small rocket engine; and the Model 1010, which offers straight-through flow for negligible pressure drop.

Write in No. 446 on Reader Service Card
more on page 3025



New Norden
"disc" design
creates



High count, multiple turn Gray encoders ... without indexing mechanisms

Norden engineers have succeeded in incorporating double brush logic in a Gray encoder, model ADC-16-GRAY, achieving multiple turn capabilities and high resolution per turn... without the need for between-stage indexing mechanisms.

Norden ADC-GRAY code units:

- meet or exceed military specifications.
- assure freedom from error due to positional ambiguities.

- are the smallest multi-turn Gray encoders available, and store nearly twice as much in a given diameter as units using a pure binary code.
- eliminate ambiguity situations caused by cross-coupling, simplifying telemetering problems such as may arise in space satellites.

Norden offers several models in Gray-code encoders with a total count range of 2^8 to 2^{16} . Review your requirements and send for detailed specifications and drawings or call TRinity 4-6721.

TYPICAL MODELS	TOTAL COUNT	REVOLUTIONS FOR FULL COUNT	DIAMETER
ADC-16-GRAY	65536	64	3.25
ADC-ST10-GRAY	1024	1	3.25
ADC-ST9-GRAY	512	1	2.25
ADC-ST8-GRAY	256	1	1.75



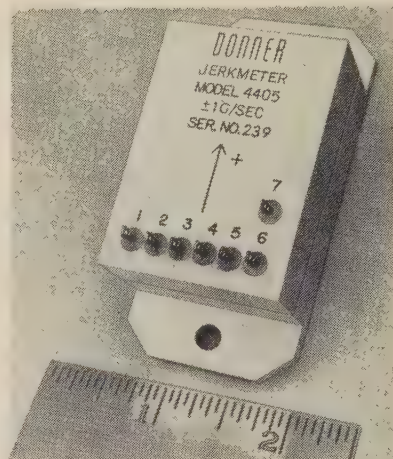
NORDEN

DIVISION OF UNITED AIRCRAFT CORPORATION

Milford Department, Wiley Street, Milford, Connecticut

Write in No. 380 on Reader Service Card at start of Product Preview Section

JERKMETER
is very accurate

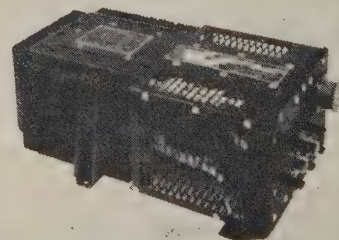


The rate of change of acceleration in airborne vehicles can now be measured with an instrument that is accurate to 0.1 per cent, according to Doner Scientific Co., Dept. S/A, Concord, Calif. Acceleration range is one to +30 g full range, and jerk range is ± 0.5 to ± 20 g full range.

The jerkmeter is available in both linear and angular versions, and both provide output voltages that can be used to instigate compensatory control forces. The 3.5-oz, three-in-long unit can also be used where constant acceleration is required, for providing a third order term for stabilizing displacement devices, and as an inertial indicator of first motion.

Write in No. 447 on Reader Service Card

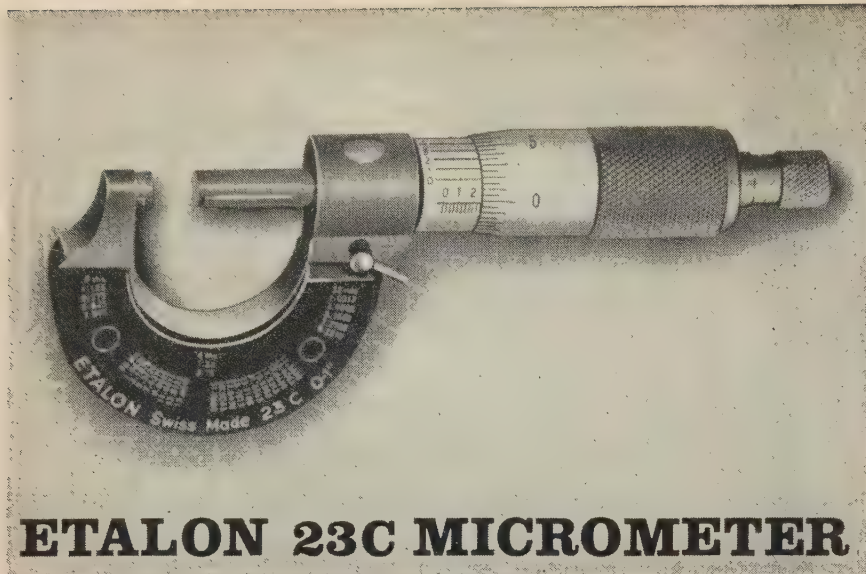
TRANSFORMER RECTIFIER
has high amperage



Model W-1206-1, 200 ampere Static Transformer Rectifier weighs less than 28 lb and is capable of continuous operation at 200 amperes with an input voltage from 190 to 210 volts, 3 phase, and an input frequency between 380-420 cps, says Electrosolids Corp., Dept. S/A, 13745 Saticoy Street, Panorama City, Calif.

The unit will meet MIL-P26198 and recently received Air Force approval. The maximum no load voltage 36.7 V dc. The design provides efficiency exceeding 90 per cent with a maximum ripple of 1.5 V peak. The unit will operate continuously without servicing for more than 10,000 hrs.

Write in No. 448 on Reader Service Card
more on page 304



ETALON 23C MICROMETER

one piece stainless steel spindle

HARDENED AND GROUND FROM THE SOLID

- Reads to .0001" • Heavy duty tungsten carbide measuring faces • Forged frame • Dull chrome finish on thimble and barrel
- Quick acting positive lock • Built for accuracy under the most rugged applications • Furnished in handsome contour case



AVAILABLE INDIVIDUALLY OR IN SETS FROM 0 to 12"
WRITE FOR CATALOG on complete line of precision measure instruments

ALINA CORPORATION

122 East Second St., Mineola, L.I., N.Y.

Write in No. 381 on Reader Service Card at start of Product Preview Section

Mastergauge
by
MARSH

Nothing could be finer!

Mastergauge alone brings you "Conoweld" leak-proof, one-piece tubing and socket; sturdier Marshalloy case; precision mastergauge movement; stainless tube and socket when required.

Mastergauge is standard bearer for the broad line of Marsh Gauges for every service.

MARSH INSTRUMENT COMPANY, Dept. 43, Skokie, Ill.
Division of Colorado Oil and Gas Corporation

Marsh Instrument & Valve Co. (Canada) Ltd., 8407 103rd St., Edmonton, Alberta
Houston Branch Plant, 1121 Rothwell St., Sect. 15, Houston, Texas



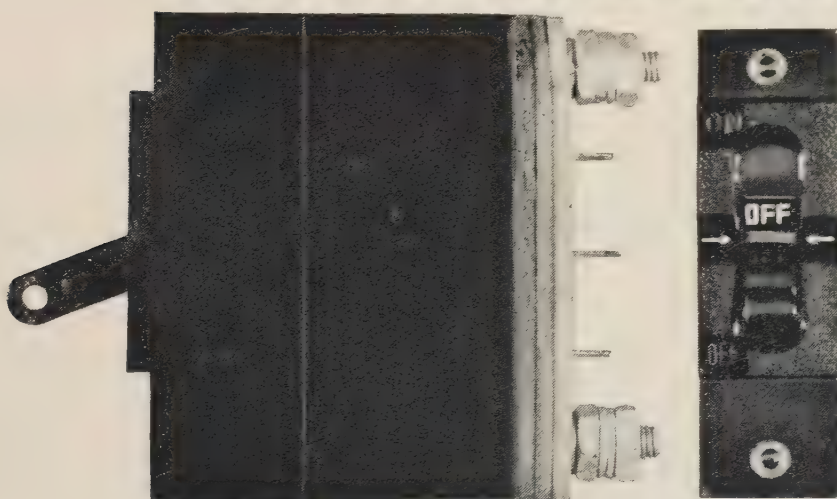
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TRIPS

ON AS LITTLE AS
20 MILLIAMPS

NEW HYNETIC^{*}
BREAKER FROM
WESTINGHOUSE



Full range of ratings as low as 20 milliamps.

Hynetic
(actual size)

Three hundred and sixty standard ratings for quick delivery . . . specials on request. This compact, sturdy unit is available in a variety of tripping characteristics: standard time delay, short time delay, instantaneous trip. Auxiliary switch optional. Breaker available from 20 milliamps to 50 amps—with maximum voltage range 250 volts a-c or 50 volts d-c.

Call your local Westinghouse Sales Representative for a demonstration of the Hynetic breaker, or write or wire Standard Control Division, Westinghouse Electric Corporation, Beaver, Pa.

J-30314

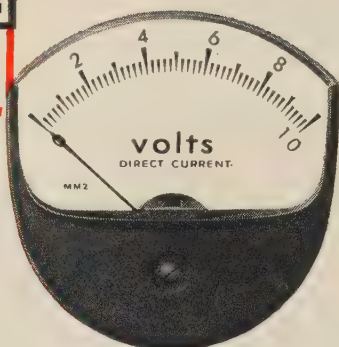
^{*}Hynetic is the Westinghouse trade-mark for its new hydraulic-magnetic breakers designed specifically for the electronics industry.

YOU CAN BE SURE...IF IT'S

Westinghouse

WATCH "WESTINGHOUSE LUCILLE BALL-DESI ARNAZ SHOWS" CBS TV ALTERNATE FRIDAYS

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MEDALIST* meters

Combine increased readability with attractive color styling. ASA/MIL 1 1/2", 2 1/2" and 3 1/2" mounting. Up to 50% longer scale in same space as conventional types. Standard and special colors. Bulletin on request. Marion Instrument Division, Minneapolis-Honeywell Regulator Co., Manchester, N.H., U.S.A. In Canada, Honeywell Controls Limited, Toronto 17, Ontario.

Honeywell
First in Control



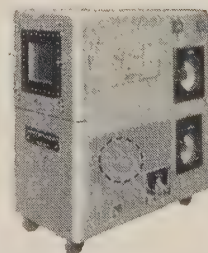
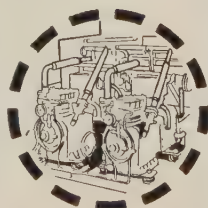
Write in No. 384 on Reader Service Card

CINCINNATI SUB-ZERO CHAMBERS have the FINEST REFRIGERATION SYSTEMS

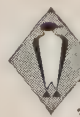
Compact, so units occupy minimum floor space . . . fully automatic controls for testing under conditions of hi-lo temp, humidity, radiation, and altitude . . . through

Custom Engineered Design

- Hermetically sealed compressors
- Overload and under-voltage protection
- Pressure and electrical safety controls
- Refrigerants and refrigeration systems in accordance with nationally approved standards of design
- Air or water cooled systems
- Loss of refrigerants minimized by pressure equalization



"Visit our Booth 409, ASTE Tool Show, Detroit, April 21-28"



**CINCINNATI
SUB-ZERO PRODUCTS**

General Offices & Plant
3930-V Reading Rd. • Cincinnati 29, Ohio

Representatives in major industrial areas
Member: Environmental Equipment Institute

Write in No. 385 on Reader Service Card

PRODUCT PREVIEW

WWV RECEIVER is small in size

The Model WWVT is a battery-operated, transistorized WWV receiver designed especially for remote operations in the communications and general electronic fields, among others. The six-lb device has a sealed metal case and potted components, and it is suitable for use under extreme environments, says Specific Products, Dept. S/A, 21051 Costanso St., Woodland Hills, Calif.

Features of the receiver include crystal controlled carrier frequency, an S meter to indicate signal strength, and two-uv sensitivity. Included are a self-contained antenna, high-low impedance antenna inputs, and phone jack and speaker.

Write in No. 449 on Reader Service Card

TACHOMETER GENERATOR needs no compensation

Model U720-001 is a rugged, reliable size 20 tachometer generator which has an output voltage linearity of 0.03 percent without the need for compensation due to temperature variations. The unit exhibits other features such as very slight frequency change between input and output voltages and an output voltage variation of ± 0.1 per cent, says Kearfott Co. Inc., Dept. S/A, 1500 Union Ave., Clifton, N.J.

Because of the relatively small power input, the temperature rise of the unit is only 12-14 deg C. The tachometer generator has a rotor moment of inertia of 63 gm² and weighs only 29 oz.

Write in No. 450 on Reader Service Card

FERRITES for 2000 m

The most outstanding advantage of this group of ferrites is its extremely low saturation magnetization. Type MCL1110 has a saturation magnetization of 1200 gauss/cc; Type MCL1116, 600 gauss/cc; and type MCL1118, 800 gauss/cc, says Microwave Chemicals Lab, Inc., Dept. S/A, 282 7th Ave., New York 1, N.Y.

All three types are available in standard sizes and shapes.

Write in No. 451 on Reader Service Card

PULSE CONVERTER is self-contained

This expanded scale megacycler is a static, self contained precision detector which converts pulse rate to directly proportional dc voltage or current. By means of a static zero suppression circuit, it furnishes full scale output signals over a selected narrow frequency range of input signal, says Pioneer Magnetics, Inc., Dept. S/A, 5858 Wilshire Blvd., Los Angeles 36, Calif. Built-in or remote attenuators allow convenient, continuous adjustment of both the zero setting and the range scale over wide limits.

Type ES 400, model 1000-W unit has a mid-frequency range of 400 cps and will supply 0-1 vdc when the input signal varies from 380 cps to 420 cps.

Write in No. 452 on Reader Service Card

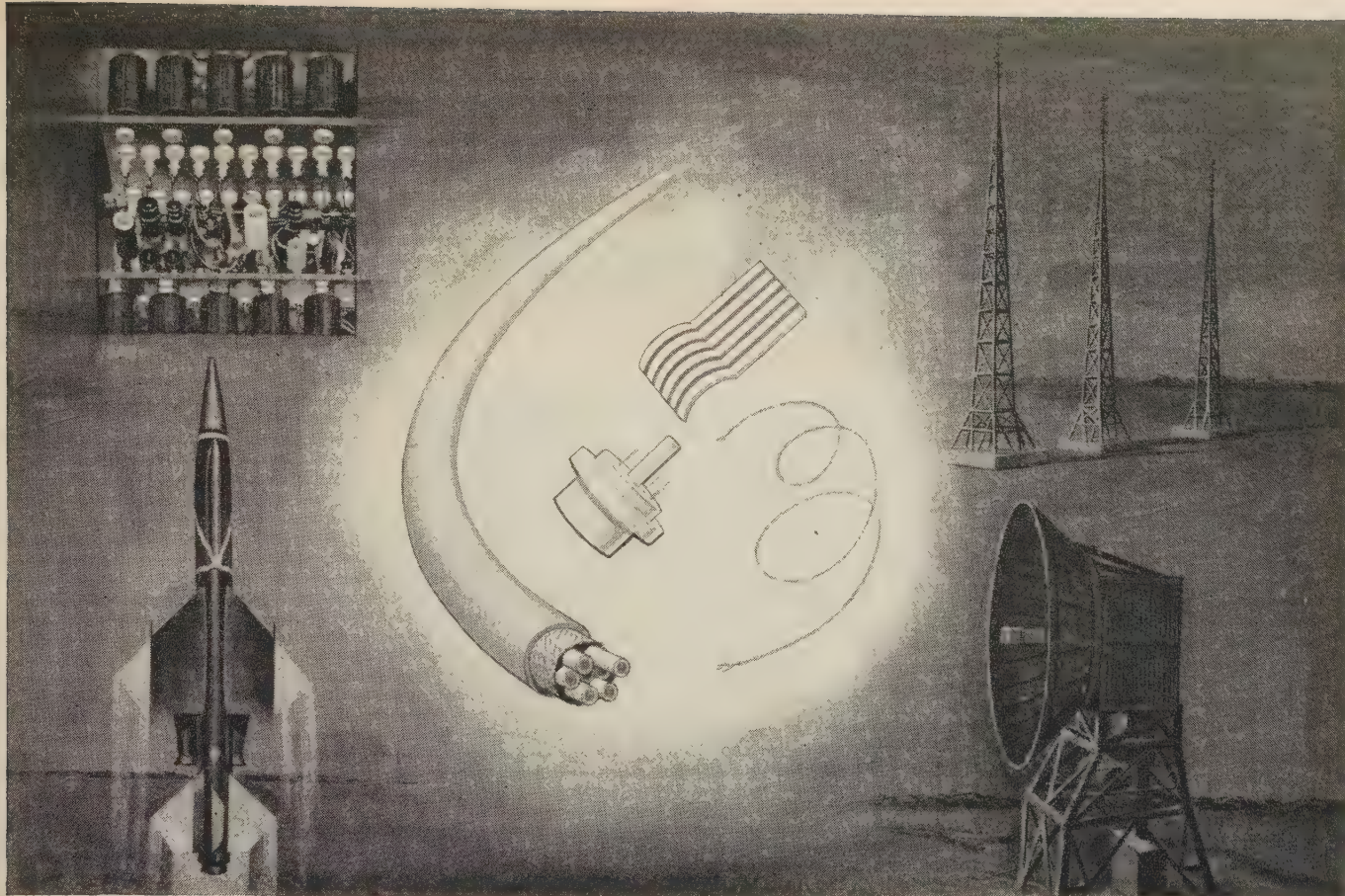
TANTALUM CAPACITORS are ruggedized

Designed to meet applicable military requirements MIL C-3965B, types CL-15, 39, 40, and 43 tantalum capacitors have ratings up to 150 mfd at 30 V and 50 mfd at 90 V. Operating temperature range is from -55 deg C. to +125 deg C, says Magnavox Co., Dept 822, Dept. S/A, Fort Wayne, Ind.

Units are hermetically sealed and will meet salt spray shock vibration, moisture resistance, reduced pressure and similar tests.

Write in No. 453 on Reader Service Card

more on page 30



NOW COMMERCIALY AVAILABLE—

New **TEFLON® 100** FEP Resin...for a new wide range of improved electrical designs

With the commercial availability of TEFLON 100 FEP-fluorocarbon resin—a new, melt-processible fluorocarbon resin—the family of TEFLON resins now offers an outstanding combination of properties for use in a wider range of electrical and electronic equipment than ever before. TEFLON FEP resins can be molded and extruded by techniques commonly used with thermoplastic polymers. TEFLON FEP resin has unmatched electrical properties over a wide range of temperatures and frequencies. Parts fabricated from TEFLON FEP resin have excellent heat resistance . . . are capable of continuous service at temperatures up to 400°F. and higher under certain conditions. They are inert to virtually all chemicals and solvents. They have a very low coefficient of friction. They are tough, strong, and display excellent weatherability.

And because TEFLON FEP-fluorocarbon resin is melt-processible, it can be extruded as jackets for wire and cable . . . as long, continuous lengths of wire insulation . . . and rapidly fabricated into complex shapes.

The new opportunities for improved design offered by

TEFLON FEP resin are particularly important in aeronautic and space applications . . . wherever there is a premium on the utmost reliability, simplified assembly, savings in weight and space through miniaturization.

For more information about the properties and applications of TEFLON fluorocarbon resins, including additional data on the characteristics of the new FEP resin, write to us, mentioning your field of interest. Address: E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Dept. T-64, Room 2526, Wilmington 98, Delaware.

In Canada: Du Pont of Canada Limited, P. O. Box 660, Montreal, Quebec.

TEFLON is Du Pont's registered trademark for its family of fluorocarbon resins, including TFE (tetrafluoroethylene) resins and FEP (fluorinated ethylene propylene) resins.



TEFLON®
FLUOROCARBON RESINS

BETTER THINGS FOR BETTER LIVING...THROUGH CHEMISTRY

Write in No. 386 on Reader Service Card at start of Product Preview Section

Corrosion-Fighting Titanium Sheet Paves Way for Honeycomb in Navy A3J



Titanium metal's corrosion resistance has enabled North American Aviation designers to draw upon the stiffness and light weight inherent in honeycomb-core construction for the inlet guide ramp of the Navy's Mach 2 attack aircraft, the A3J Vigilante.

- Titanium metal, immune to salt water corrosion build-up, proved so effective in replacing aluminum cover sheets and channels that existing A3J aircraft can be retrofitted with the new design. The overall weight saving—implying a design bonus—is 22 percent.

Installation of titanium in the inlet ramp assembly is the latest step in a continuing trend of designers capitalizing on titanium's unique combination of intrinsic properties: low density (0.16 lb./cu. in.), great strengths, outstanding corrosion resistance, and ability to retain its properties under long-term exposure from -300°F up through intermediate temperature ranges. Its effectiveness under conditions of short-time exposure was seen in its use as the nose-cone tip of the Vanguard where titanium withstood temperatures of 1500°F .

The A3J inlet ramps are made of flat, tapered titanium sheets adhesive-bonded to an aluminum honeycomb core. Each assembly is about 5 ft. long, 2 ft. wide, and 3 in. thick, with 16,000 holes drilled through the skin, to control air flow to the engine. Because a large volume of air flows through the holes, a small amount of corrosion product build-up would seriously impair the ramp's performance.

An integral part of the panel is an I-beam-shaped titanium rib which connects the ramp to the actuator. This rib, machined by North American from a Ti-6Al-4V alloy, is the only titanium part in the inlet ramp assembly.

at-treated forging, weighs about lb., and is riveted into the panel. To take advantage of the corrosion resistance properties of titanium in this application, North American worked out two machining operations and an adhesive bonding technique.

MILLING THE FACE PLATES: The titanium face plates are tapered, from .990 in. thick at one end to 0.045 in. at the other. This taper is achieved by milling the sheet, in one pass, with HSS cutters. During the operation, the work is completely submerged in a solution of one part denatured alcohol and three parts water. Cutting speed is 180 rpm, with feed rates from 5 to 20 ipm.

ADHESIVE BONDING: The tapered skin is bonded to the honeycomb core with Bloomingdale Rubber Company's HT-424 adhesive. A four-step preparation was developed for this operation: vapor de-grease, acid pickle (25-35% HNO₃ plus 2-4% HF), application of fluoride phosphate coating, and hot water rinse.

DRILLING 16,000 HOLES: After the skin is bonded to the honeycomb core, 16,000 holes 0.050 to 0.060 in. diameter are multi-spindle drilled through the skin, in a milling machine setup with a 130-spindle gearless drillhead. The HSS drills have short shanks, to minimize wear and breakage. Cutting fluid is a soluble-oil emulsion. North American's use of titanium is primarily for corrosion resistance

highlights one of the properties of titanium metal attractive in construction of:

● **ENGINES:** Titanium metal eliminates the possibility of stress-corrosion or salt-water-spray pitting with its consequent fatigue damage of compressor, turbine blades and other engine parts. This is of unusual importance to commercial carriers who expect their new jets to operate 8 to 10 trouble-free hours daily. Weight advantages can provide significant economies in fuel savings alone, during seven years of operation.

● **MISSILES:** Titanium metal provides excellent resistance to the corrosive effects of rocket fuels such as liquid fluorine and ammonium perchlorate, at the same time providing minimum weight structure and outstanding cryogenic properties.

Price reductions in titanium metal and mounting experience in working with titanium have enabled fabricators to produce assemblies with competitive advantages that more than outweigh materials cost differentials.

Titanium Metals Corporation of America has dedicated its full resources to development and production of high-strength, aircraft-quality titanium and offers the technical assistance that you may require. This effort to build a titanium industry has provided TMCA with a wealth of information that is yours when you specify Timet® titanium.

Send for: Titanium Machining Techniques, a new 32-page technical publication reviewing practical methods for turning, milling, drilling, tapping, reaming, broaching, routing, grinding and sawing of titanium.

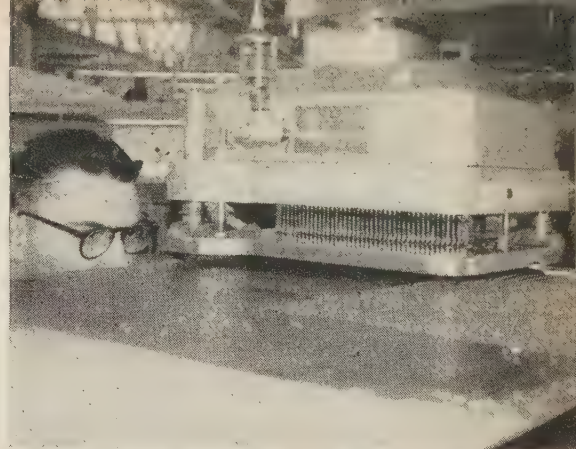
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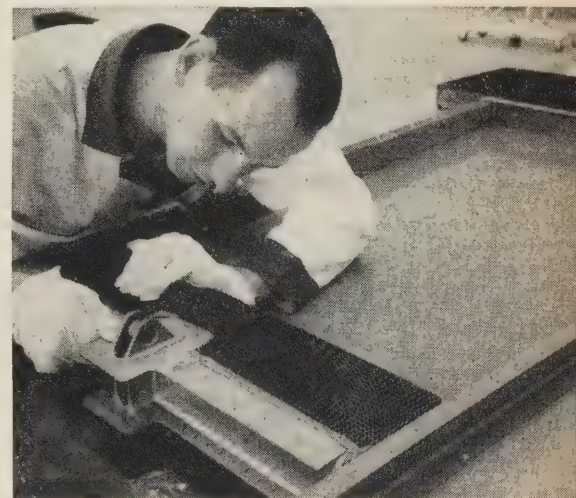
**TITANIUM METALS
CORPORATION OF AMERICA**

233 Broadway, New York 7, N. Y.

Write in No. 387 on Reader Service Card at start of Product Preview Section



MULTI-SPINDLE DRILLHEAD mounted in milling machine makes 130 holes per pass. Surface has 16,000 holes 0.050 to 0.060 in. in diameter. Former parts were made of aluminum, which corroded and interfered with proper air flow



HONEYCOMB CORE MATERIAL is being adhesive-bonded to titanium spar (machined from Ti-6Al-4V forging), and will subsequently be bonded to tapered titanium sheet. Total weight saving of 22% is a bonus to the manufacturer. Titanium was chosen for its corrosion resistance



ULTRASONIC PROBE TESTS for completeness of bond between core and skin. Bracket at center of ramp assembly is part of a Ti-6Al-4V titanium rib, machined at North American from a Wyman-Gordon Company forging. Bracket is connected to actuator, to control pitch of inlet guide ramp

STAINLESS STEEL TUBING

Pressures demanded by missile, rocket and supersonic aircraft hydraulic and pneumatic systems of current military specifications are emphatically resisted by dependable PATCO stainless steel tubing.

PATCO Stainless Steel Tubing, as well as PATCO Carbon and Alloy Steel Tubing, is produced in lengths up to 55 feet. PATCO also produces cold drawn bars—rounds, squares, hexagons—in carbon and alloy steels. Your orders for stainless, carbon or alloy steel tubing, as well as cold drawn bars, are promptly shipped when sent to either Pacific Tube or your local Steel Service Center.

Next time, specify
PATCO tubing and bars.

patco

**PACIFIC
TUBE CO.**

5710 SMITHWAY STREET • LOS ANGELES 22, CALIF. • RAYmond 3-1331
WESTERN REPRESENTATIVE FOR SUPERIOR TUBE CO.

PRODUCT PREVIEW

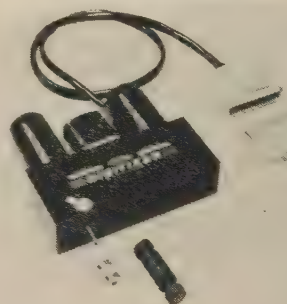
DIGITAL VOLTMETER is all solid-state

This DVM is a multi-output data converter consisting of a voltage-to-digital converter and a digital display. The unit measures bipolar d-c voltages ranging from 1mv to 1000 V. Accuracy is ± 0.1 per cent and speed is 100 conversions per sec, says Epsco, Inc., Dept. S/A, 275 Massachusetts Ave., Cambridge, Mass.

The output is automatically displayed as a 3 decimal digit readout plus an overflow digit, sign and decimal point. Electrical outputs include parallel BCD coded voltages and a serial pulse train for single wire telemetry use.

Write in No. 454 on Reader Service Card

DECIMAL DIGITIZER is multi-speed type



This decimal digitizer is a non-ambiguous electromechanical shaft position encoder of the absolute positional multi-speed type. It features 10, 40, 100, 400, and 1000 counts per rotation, continuous on demand readout, and ability to operate parallel entry printers directly, says Coleman Electronics, Inc., Dept. S/A, 133 E. 162 St., Gardena, Calif.

The digitizer is available in three, four, five, or six decade units.

Write in No. 455 on Reader Service Card

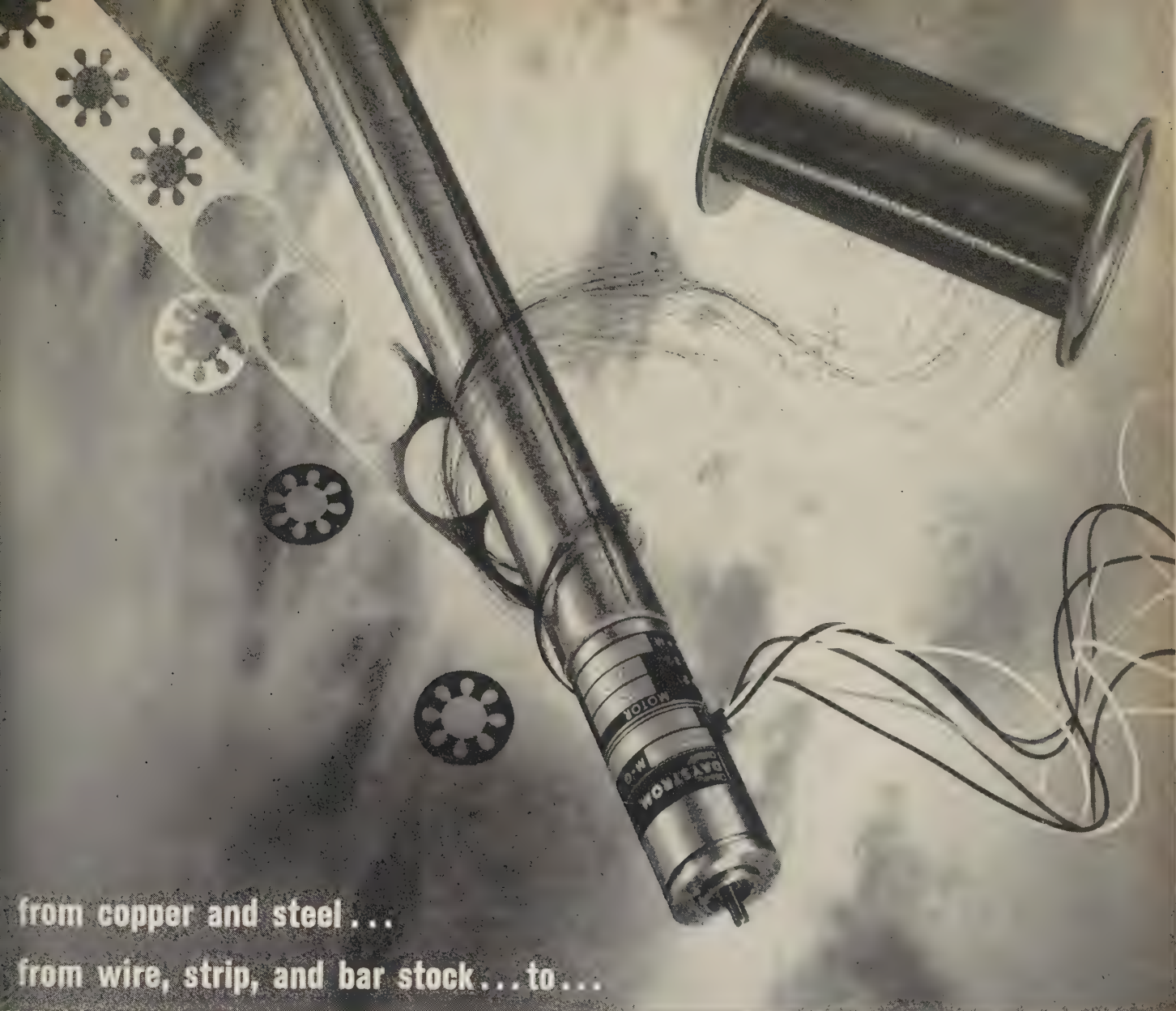
RELAY handles larger loads

The JH-6D two-pole, subminiature, crystal relay can switch larger loads and resist higher-g values for shock and vibration than larger relays, says Allied Control Co., Inc., Dept. S/A, 2 E. End Ave., New York 21, N. Y. The 0.8-oz, 1 x 0.8 x 0.4-in device is rated for low level to five amps, and it is available with plug-in, printed circuit and hook-type solder terminals.

Sensitivity of the relay permits its use in plate circuits of tubes, or with transistors. The device can be adjusted to pull in as low as 100 mw with a maximum contact rating of two amps, non-inductive, at 29 V dc or 115 V ac. Operate time is ten msec max and release time five msec maximum. Ambient temperature range is -65 to $+125$ deg C.

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Write in No. 388 on Reader Service Card at start of Product Preview Section



from copper and steel ...
from wire, strip, and bar stock ... to ...

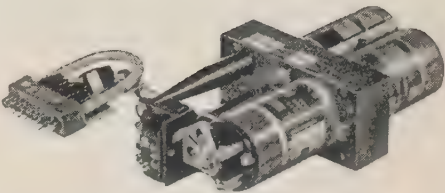
COMPLETE SERVO ASSEMBLIES

We are not an assembly station. We are a manufacturer!

Steel and copper come into our factory. Housings are turned and gears are hobbled from the solid stock. Laminations are stamped from strip steel. Copper is wound right off the reel.

Every operation between raw stock and servo assembly is performed in our own plant, under our own supervision. And because we exercise this complete control over manufacture, we can honestly vouch for the quality and reliability of every motor, generator, synchro, and gear train carrying our name.

Undivided responsibility isn't a new idea by any means, but it is increasingly difficult to find in this age of overspecialization. If you'd care to sample the benefits of this integrated approach, why not call on us now?



SERVO ASSEMBLY - Type 9 motor generator driving two Type 11 CT synchros through a slip clutch and a gear train having ratio of 1500 to 1.

DAYSTROM, INCORPORATED

TRANSICOIL DIVISION

WORCESTER • MONTGOMERY COUNTY • PENNSYLVANIA

Write in No. 389 on Reader Service Card at start of Product Preview Section



Meeting the challenge in new materials . . .

Swedlow achieves new shapes in molded chopped fabric high temperature parts

Nothing quite like this reinforced high temperature part had been produced before. But the tail cone for Bureau of Naval Weapon's Tartar missile called for walls nearly 6" high, with thicknesses ranging from .090" to more than 1". The shape was complex, the tolerances close. Strength and temperature resistance requirements were high. Working closely with Convair/Pomona, Convair Division of General Dynamics, prime contractor for Tartar, Swedlow engineers assisted in the design and producibility of this extremely critical unit. They utilized an especially formulated chopped fiberglass pre-impregnated high temperature silicone resin system. Swedlow is now successfully producing the assembly, combining superior materials knowledge with skills in press molding, controlled curing and machining to close tolerances, and secondary bonding.

Call on Swedlow next time you have a challenging materials problem. Write for new facilities report "Z," and complete technical information. Please refer to Dept. 25.



SWEDLOW INC./LOS ANGELES 22, CALIFORNIA/YOUNGSTOWN 9, OHIO

Write in No. 390 on Reader Service Card at start of Product Preview Section





data preview

PLATING—The Dalic process of electroplating is described in a brochure prepared by Sifco Metachemical, Inc., Dept. S/A, 935 E. 63 St., Cleveland, Ohio. It illustrates various applications.

Write in No. 457 on Reader Service Card

CABLES—An eight-page facilities report covering its manufacturing facilities has been prepared by Sequoia Wire & Cable Co., Dept. S/A, 2201 Bay Rd., Redwood City, Calif. Areas considered include plant equipment, production capabilities, and typical products suitable for electronic and other applications.

Write in No. 458 on Reader Service Card

IMPREGNATION—A variety of vacuum impregnators that are useful in the missile and electronic manufacturing fields, among others, have been described in a catalog issued by J. P. Devine Mfg., Dept. S/A, 49th St. & A. V. R. R., Pittsburgh, Pa. Applications listed in the six-page folder include resin impregnation of metal parts for high altitude aircraft and missiles.

Write in No. 459 on Reader Service Card

SPINDLES—The complete line of Super Precision spindles for the machining of the exotic metals though the electrolytic process has been described in Catalog 22A, a 20-page publication available from The Standard Electrical Tool Co., Dept. S/A, 2488-96 River Rd., Cincinnati 4, O. Spindles are available for 50 to 3000-amp capacity and can be mounted on existing machine tools, spar and skin millers, and other equipment.

Write in No. 460 on Reader Service Card

ALTITUDE TESTING—A brochure illustrated with drawings and photographs of the layout and equipment of altitude-test facilities for aircraft engines has been issued by Rolls-Royce Ltd., Dept. S/A, Derby, England. T. S. D. Publication 1190 reports that the test plant is capable of thoroughly testing any turbo-prop or turbo-jet engine envisioned within the next few years.

Write in No. 461 on Reader Service Card

THYRATRONS—A technical Bulletin entitled "Thyratrons Are Different" explains the mechanism of ionization, describes the "critical and characteristic" curve, and discusses the effects of temperature on ionization time and tube life. The bulletin, Pa-223, is available from CBS-Electronics, Dept. S/A, Parker St., Newburyport, Mass.

Write in No. 462 on Reader Service Card

MICROWAVE DESIGN—A 320-page, hard cover book giving complete information on making microwave measurements and providing comprehensive theory plus practical help on applications is available from De-Mornay-Bonardi, Dept. S/A, 780 S. Arroyo Pkwy., Pasadena, Calif. Catalog contains an expanded handbook section giving the latest tabulations on available microwave tubes and their characteristics.

Write in No. 463 on Reader Service Card

ANTENNAS — Reflection antennas especially designed and fabricated for celestial study, missile and satellite tracking, and radar control, are highlighted in a new booklet #2556 available from Blaw-Knox Co., Dept. S/A, 300 Sixth Ave., Pittsburgh, Pa. The 12-page booklet illustrates equatorially mounted, azimuth elevation, and stationary type antennas and outlines specifications for some of these units.

Write in No. 464 on Reader Service Card

HOLDING VALVES — Engineering data sheets detailing its series 25700 holding valves have been issued by Sarasota Precision Products, Inc., Dept., S/A, 1312 N. Lime Ave., Sarasota, Fla. They contain engineering and design information, schematic drawings, typical circuit applications, flow characteristics approved J.I.C. symbols, and dimensions.

Write in No. 465 on Reader Service Card

HORSEPOWER NOMOGRAM—A dual nomogram for horsepower, torque and applicable to fractional horsepower motors and transmissions is provided in an engineering data sheet by Merkle-Korff Gear Co., Dept. S/A, 213 N. Morgan, Chicago 7, Ill. RPM scale from .5 to 500 rpm; torques to 300 pound-inches and 600 pound-feet, horsepower scales for corresponding product values of torque and RPM.

Write in No. 466 on Reader Service Card

MOLDING COMPOUNDS — General data on properties and uses of thermosetting phenolic and diallyl phthalate molding compounds, fire-retardant Hetron polyester resins for reinforced plastics, and phenolic resins for bonding and coating are discussed in bulletin No. D400 issued by Hooker Chemical Corp., Durez Plastic Div., Dept. S/A, No. Tonawanda, N. Y. Product application photos, and a table of values and a chart of typical properties are included.

Write in No. 467 on Reader Service Card

TRANSDUCERS — The Hi-Ac-Tran model 106 transducer, designed to connect control computers to pneumatic equipment, is described in bulletin No. E-106 by Associated Control Equipment, Inc., Dept. S/A, P. O. Box 136, 853 Fourth Ave., Coraopolis, Pa. It explains principle of operation, outlines pneumatic and electrical rating specifications, performance data, and special features.

Write in No. 468 on Reader Service Card

TUBES—An 18-page colored booklet describing their new electron tubes for 1959 is available from Eitel-McCullough, Inc., Dept. S/A, San Carlos, Calif. The booklet describes many of the experimental tubes developed at the laboratories and now in production.

Write in No. 469 on Reader Service Card

PLANT FACILITIES—Design services and manufacturing facilities from concept to finished product are described in a brochure by Breeze Corp., Dept. S/A, 700 Liberty Ave., Union, N. J. Its products in the electro-mechanical and hydromechanical fields include radio shielding, generators, actuators and ignition systems to welded bellows units and cargo and rescue winches.

Write in No. 470 on Reader Service Card

TRANSFORMERS — 1960 catalogs covering the complete line of transformer and filter products are available from United Transformer Corp., Dept. S/A, 150 Varick St., New York 13, N. Y.

Write in No. 471 on Reader Service Card

SWITCHES—Four groups, type "V3" postage-stamp-size switches, "TB" 2-circuit switches, 1sX1 sub-sub-miniature switches and "SM" sub-miniature—are described in catalog No. 63 by Minneapolis-Honeywell Regulator Co., Micro Switch Div., Dept. S/A, Freeport, Ill. It is intended as a guide for designers of electronic, airborne, commercial and military equipment.

Write in No. 472 on Reader Service Card

VARIABLE RESISTORS—Tabular comparative data and technical description of the 1/2" diameter high temperature series 660 Cera-Trols variable resistors using metal-ceramic resistance element are contained in data sheet 175 by Chicago Telephone Supply Corp., Dept. S/A, Elkhart, Ind. It is illustrated and contains dimensional drawings.

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more on next page

Flame spray refractory coatings at high speed—low cost

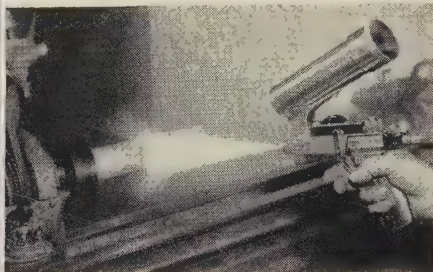
Alumina—zirconia—tungsten carbide—for protection against high temperatures—blast abrasion.



Rocket nose cone of metallic tungsten, flame sprayed on salt-covered mandrel. Salt is leached out with water to free finished part.



METCO Type 2P ThermoSpray Gun flame sprays a wide range of material in powder form, including tungsten carbide. Plasma flame spray equipment also available.



METCO Type KD Machine flame sprays alumina and zirconia in rod form; provides highest application speeds for guns of this type—over 90% deposit efficiency.

METCO offers a complete range of flame spraying equipment for applying coatings of refractories and other high melting-point materials. Automatic electronic controls provide push-button operation for high-speed production, maximum deposit efficiencies.

METCO Bulletin 136B provides basic engineering and application data on flame sprayed coatings of metals, ceramics, carbides and other high melting-point materials. Send off the coupon or write.



Metallizing Engineering Co., Inc.

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name _____	title _____
company _____	
address _____	
city _____	zone _____ state _____

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DATA PREVIEW

HERMETIC SEALING—A comprehensive brochure showing techniques for researching, developing and producing hermetically sealed components and assemblies for industry and the military has been prepared by General Hermetic Sealing Corp., Dept. S/A, 99 E. Hawthorne Ave., Valley Stream, N.Y. Bulletin No. 426 contains a leak rate comparison table.

Write in No. 474 on Reader Service Card

SERVO—Information on designing and analyzing servo systems without need for fabrication of expensive intermediate prototypes is detailed in a comprehensive report offered by Servo Corp. of America, Dept. S/A, 111 New South Rd., Hicksville, N. Y. Equipped with just block schematic and screwdriver, the report explains, the servo system designer can go from idea to the final prototype in one quick step.

Write in No. 475 on Reader Service Card

ARMAMENT CONTROL — Bulletin SPJ-4-658 detailing experience in radar, infrared amplidynes, servo-mechanisms, lead-computing gun sights, bomber defense systems, and guidance and control units for missiles is available from General Electric Co., Light Military Electronics Div., Dept. S/A, 600 Main St., Johnson City, N. Y. The bulletin also describes new Bantam avionic system.

Write in No. 476 on Reader Service Card

DYNAMOMETER—Bulletin #91, describing its elastic loop dynamometer has been issued by Thwing-Albert Instrument Co., Dept. S/A, Penn St. & Pulaski Ave., Philadelphia 44, Pa. It outlines the manner in which variable sensitivity control permits tension loads to be measured over a scale of 1000 divisions.

Write in No. 477 on Reader Service Card

VARIABLE RESISTOR—A compact, 12½:1 ratio, 15/16-in. diameter, vernier carbon variable resistor has been described in Data Sheet 174 by Chicago Telephone Supply Corp., Dept. S/A, Elkhart, Ind. Electrical and mechanical specifications are included for the Type VA-45, which is designed for fine tuning applications.

Write in No. 478 on Reader Service Card

MONITOR SYSTEM—A 4-page illustrated brochure describing their take-off monitor system is available from Minneapolis-Honeywell Regulator Co., Aeronautical Div., Dept. S/A, 2600 Ridgeway Rd., Minneapolis 13, Minn. The system is presented as a simple and practical means of monitoring aircraft performance during takeoff and provide the pilot with pertinent information so obtained.

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more on page 314



KEEP A COOL HEAD...UAP CAN SOLVE YOUR ELECTRONIC CONTROL PROBLEM!

UAP has the specialized capabilities needed to analyze your overall problem; design the system technique; integrate components and sub-systems into complete operational systems to achieve specific functions such as *temperature, mechanical and mass flow control*.

Example: Temperature control was assigned to UAP for the new shipboard radar tracking system developed by Sperry Gyroscope, which includes a TV Camera developed by DuMont Laboratories. Components of UAP Mechanical Refrigeration System for temperature control of TV Vidicon tube and associated electronic equipment are: condenser and evaporator, semi-hermetically sealed compressor, blower, controls and chassis. The envelope is 14" dia. x 10" long, with half the diameter reserved for tube circuit. Capacity of 26-pound package is 275 watts at ambient 149°F. Meets MIL environmental specifications.

Send us your requirements:

UNITED AIRCRAFT PRODUCTS, INC., Dayton, Ohio
(Contractual Engineering Offices: California, Gardena FA 1-4810; New York City MU 7-1283; Dayton, Ohio BA 4-3841; Canada, Montreal OX 7-0810)
WESTERN DIVISION, UAP, Inc., Gardena, California



U-522477 Mechanical Refrigeration System



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INSTANT ROCKET EXHAUST ANALYSIS

10,000 complete analyses per second of
10,000°C. flames now possible with new

BENDIX* MASS SPECTROMETER

We offer the basic tool for analysis of fast reactions, such as plasma jets and rocket exhaust. Model 14 of the Bendix Time-of-Flight Mass Spectrometer combines a high-speed, line-of-sight sample inlet with fast pump-out of the analyzer region so necessary for this difficult analysis. Both plus and minus flame ions can be analyzed as well as neutral radicals and molecules.

Our engineering department is ready to work with you on solving your specific sample inlet problems, as well as other research and development projects in the missile and rocket field.

For complete details on this and other applications, plus a copy of The Dow Chemical Company report "Time-of-Flight Mass Spectrometry and Gas-Liquid Partition Chromatography," contact the Cincinnati Division, Dept. X4, 3130 Wasson Rd., Cincinnati 8, Ohio.

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Cincinnati Division
CINCINNATI, OHIO



Export Sales: Bendix International Division, 205 East 42nd Street, New York 17, New York
Canada: Computing Devices of Canada, Ltd., Box 508, Ottawa 4, Ontario.

Write in No. 393 on Reader Service Card at start of Product Preview Section
314

DATA PREVIEW

EPOXIES—A booklet on epoxy adhesives, sealants, alloys and coatings has been issued by H. B. Fuller Co., Dept. S/A, 255 Eagle St., St. Paul 2, Minn. Included are product description, technical data and suggested uses.

Write in No. 480 on Reader Service Card

BARREL FINISHING—A seven-point system for controlling barrel finishing is discussed in a booklet issued by Carborundum Co., Dept. S/A, Niagara Falls, N. Y. It lists tumbling media, barrel finishing compounds, and barrel finishing machines and equipment.

Write in No. 481 on Reader Service Card

RIVETS—Closed-end rivet is the subject of an illustrated flyer by United Shoe Machinery Corp., "Pop" Rivet Div., Dept. S/A Shelton, Conn. Included are dimensions, grip ranges, tensile and shear strengths and a table of required jaws and nosepieces.

Write in No. 482 on Reader Service Card

HYDRAULIC PRESS BRAKE—Hydraulic press brakes are discussed in a catalog containing specifications on models ranging in capacity from 150 to 1800 tons issued by Verson Allsteel Press Co., Dept. S/A, 9300 S. Kenwood Ave., Chicago 19, Ill. Its catalog DC-59 describes pneumatic, hydro-pneumatic and hydraulic die cushions.

Write in No. 483 on Reader Service Card

AMPLIFIER—A data sheet describing Model 4150MB Class AB, amplifier is available from MB Electronics Div., Textron Electronics Inc., Dept. S/A, P. O. Box 1825, New Haven 8, Conn.

The output of the unit is 15 KVA with a frequency range from 5 to 5000 cps.

Write in No. 484 on Reader Service Card

SILICON RECTIFIERS—A paper entitled "Thermal Fatigue and the G.E. 1N2154-60 Medium Current Silicon Rectifier" by F. W. Gutzwiller is available from General Electric Co., Semiconductor Products Div., Dept. S/A, Charles Bldg., Liverpool, N. Y. The problem of thermal fatigue due to cyclical loads is presented in various applications.

Write in No. 485 on Reader Service Card

THERMOCOUPLES — Thermocouple components and accessories are the topics discussed in catalog EN-S2 issued by Leeds & Northrup Co., Dept. S/A, 4934 Stenton Ave., Philadelphia 44, Pa. It lists and describes standard assemblies in protecting tubes and wells for general applications; specialized thermocouples and assemblies for laboratory and industrial applications; bare and insulated wires, replacement elements, ceramic insulators, metal and ceramic protecting tubes, wells, terminal heads and extension leadwires.

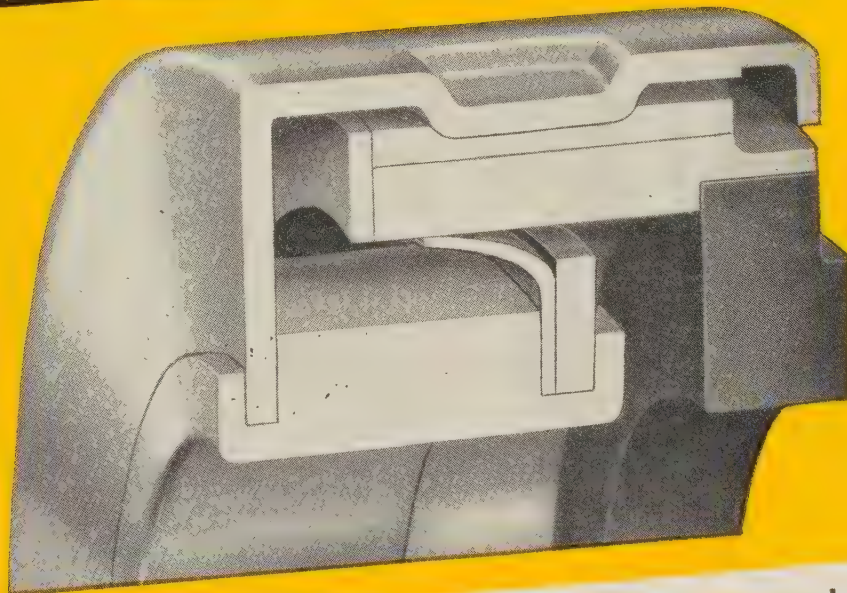
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more on page 319

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SPACE/AERONAUTICS

NEW

Only Gits Met-L-Seal* Seals at -65° to $+850^{\circ}$ F.



Now beyond the Research-Development Laboratory and into actual production — nothing like it on the market! Consider these exclusive design advantages, producing a built-in "missile reliability":

- 1** Hydraulic balance producing optimum sealing under both static and dynamic conditions — not always available in other all-metal seal designs.
- 2** Functions at temperatures, pressures and speeds in excess of capabilities of currently used organic materials — in minimum space required by aircraft-missile applications.
- 3** No internal fatigue. All components, except seal face, are made of various high-temperature alloy steels, each with the optimum combination of properties necessary to its function. (Exclusive Gits design makes Met-L-Seal operable at temperatures even higher than 850° , limited only by metallurgical progress in high-temperature alloy steels.) Positive guarantee against sudden complete operational failure and other drawbacks of synthetic-elastomer seals in extreme operating conditions.
- 4** No "shelf life" problems. No "cure-date" limitations as are necessary with synthetic-elastomer seals.

Send for new "Advance Catalog" or submit your seal problem to the experienced engineers of the Gits Aircraft and Missile Seal Division.

GITS

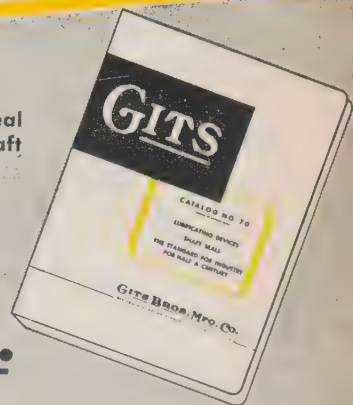
BROS. MFG. CO.

Aircraft and Missile Seal Division

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Specialists in Lubricating Devices and Shaft Seals for Almost Half-A-Century



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carbon graphite or
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seal materials

NEW DELCO 50-AMP. TRANSISTORS

HIGHER CURRENT THAN EVER BEFORE FOR MILITARY AND COMMERCIAL USE

	2N1518	2N1519	2N1520	2N1521	2N1522	2N1523
Maximum Collector Current (Amps.)	25	25	35	35	50	50
Maximum Collector to Base Volts, Emitter Open, Max I_{co} 4ma	50	80	50	80	50	80
Minimum Open Base Volts (1-Amp. Sweep Method)	40	60	40	60	40	60
Maximum Saturation Volts at Maximum Collector Current	0.7	0.7	0.6	0.6	0.5	0.5
Gain at I_c at 15 Amps.	15-40	15-40	17-35	17-35	22-45	22-45
Minimum Gain at Maximum Collector Current	12	12	12	12	12	12
Thermal Resistance Junction to Mounting Base ($^{\circ}C/Watt$)	0.8	0.8	0.8	0.8	0.8	0.8

Characteristics at 25°C Maximum Junction Temperature 95°C

A new family of high current transistors featuring the 50-ampere 2N1522 and 2N1523. Two 25- and two 35-ampere types round out the line. All thoroughly tested and completely reliable. Available in production quantities. Call or write your nearest Delco Radio sales office for full product information and applications assistance.

DELCO
DEPENDABILITY
RADIO
RELIABILITY

Division of General Motors
Kokomo, Indiana

Newark, New Jersey
1180 Raymond Boulevard
Tel: Mitchell 2-6165

Chicago, Illinois
5750 West 51st Street
Tel: Portsmouth 7-3500

Santa Monica, California
726 Santa Monica Boulevard
Tel: Exbrook 3-1465

Detroit, Michigan
57 Harper Avenue
Tel: TRinity 3-6566

Write in No. 395 on Reader Service Card at start of Product Preview Section

BRUSH SHOWS THE WAY TO FUSION WELD BERYLLIUM THE SPACE AGE METAL

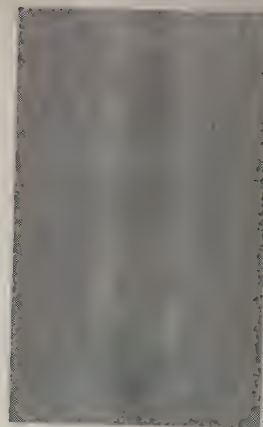


Lighter than aluminum. More rigid than steel. A high melting point material. Beryllium is all of these things. Yet, not too many years ago, its use was somewhat restricted by lack of suitable joining methods.

Now Brush engineers can show you the way to fusion weld the metal. Non-porous and crack-free beryllium weldments, with properties superior to the base metal at elevated temperatures, have been achieved. At this stage, virtually all of this welding has been done on a laboratory basis. When present development work is completed, we feel we'll be ready to try our wings, or help you try yours, on fusion welding this space age metal under production conditions.

The development of fusion welding, mechanical fastening, brazing, soldering, and other joining methods greatly broaden application horizons for beryllium.

Can this metal, its oxide, its alloys or our expanding experience with these versatile materials solve a problem for you? Let us try. Contact us at 5209 Euclid Avenue or ENdicott 1-5400 in Cleveland, Ohio.



X-ray of a one-quarter inch thick beryllium weldment.

THE BRUSH BERYLLIUM COMPANY

Write in No. 396 on Reader Service Card at start of Product Preview Section



Ever see anything so versatile as **LAMINUM**® ?

Generally, laminated shims of LAMINUM are custom stamped to blueprint specifications. Because the laminations are so easily p-e-e-l-e-d to bring the shims down to desired thickness, LAMINUM shims are used universally on assembly lines where they save time and cut costs.

But occasionally you run into a special situation—the need for a shim of *varying* thickness, for example. LAMINUM solves that problem with cost cutting ease. As illustrated, the shim is scored into quarters. Then layers are p-e-e-l-e-d from the

quarters so as to come up with varying thicknesses to correspond with variations in the job at hand.

That's LAMINUM! It's fast. Practical. Precise. No need for stand-by equipment. No machining. No grinding. No counting. No stacking. No miking. And no grit between layers—ever.

For quick estimates and service, send your prints to the Laminated Shim Company, Inc. ♦ West Coast Sales and Service 600 Sixteenth St., Oakland 12, Calif. ♦ Home Office and Plant 5304 Union St., Glenbrook, Conn.



LAMINUM is the registered trade name for Laminated Shims with layers completely surface bonded to look and act like solid metal. Design Folder No. 3 contains all facts and engineering data. Send for it.

IN BRASS ♦ MILD STEEL ♦ STAINLESS ♦ ALUMINUM ... WITH LAMINATIONS .002" OR .003"
Write in No. 398 on Reader Service Card at start of Product Preview Section

DATA PREVIEW

TRANSISTOR—A 4-page illustrated brochure, describing Mesa transistors for airborne applications is available from Motorola Inc., Semiconductor Products Div., Dept. S/A, Phoenix, Ariz.

Write in No. 487 on Reader Service Card

SERVO MOTORS—A reference sheet on Step-Servo motors sizes 5, 8, 11, 15 and 23, is available from Induction Motors of California, Dept. S/A, 6058 Walker Ave., Maywood, Calif. The material provides the general mechanical and electrical specifications for 10 different motor types and will be of particular interest to design engineers.

Write in No. 488 on Reader Service Card

TIMING DEVICES—Electronic time delay relay, E404, is described in a technical brochure, Form 59-1, issued by Wheaton Engineering Corp., Dept. S/A, 920 Manchester Rd., Wheaton, Ill. It contains charts, diagrams, and statistical tables.

Write in No. 489 on Reader Service Card

STRAIN GAGE—Bulletin No. 2294 describes an optical strain gage to measure strains due to tension and compression as small as 0.000002 in./in has been prepared by American Instrument Co., Dept. S/A, Silver Spring, Md. It contains information on operating procedure, applications, and line illustrations.

Write in No. 490 on Reader Service Card

SERVOMECHANISM—A handbook for engineers and servo system specification guide has been prepared by Superior Mfg. and Instrument Corp., Dept. S/A, 154-01 Barclay Ave., Flushing 55, N. Y. It contains detailed data on packaged systems, gear trains and heads, reducers, and other information.

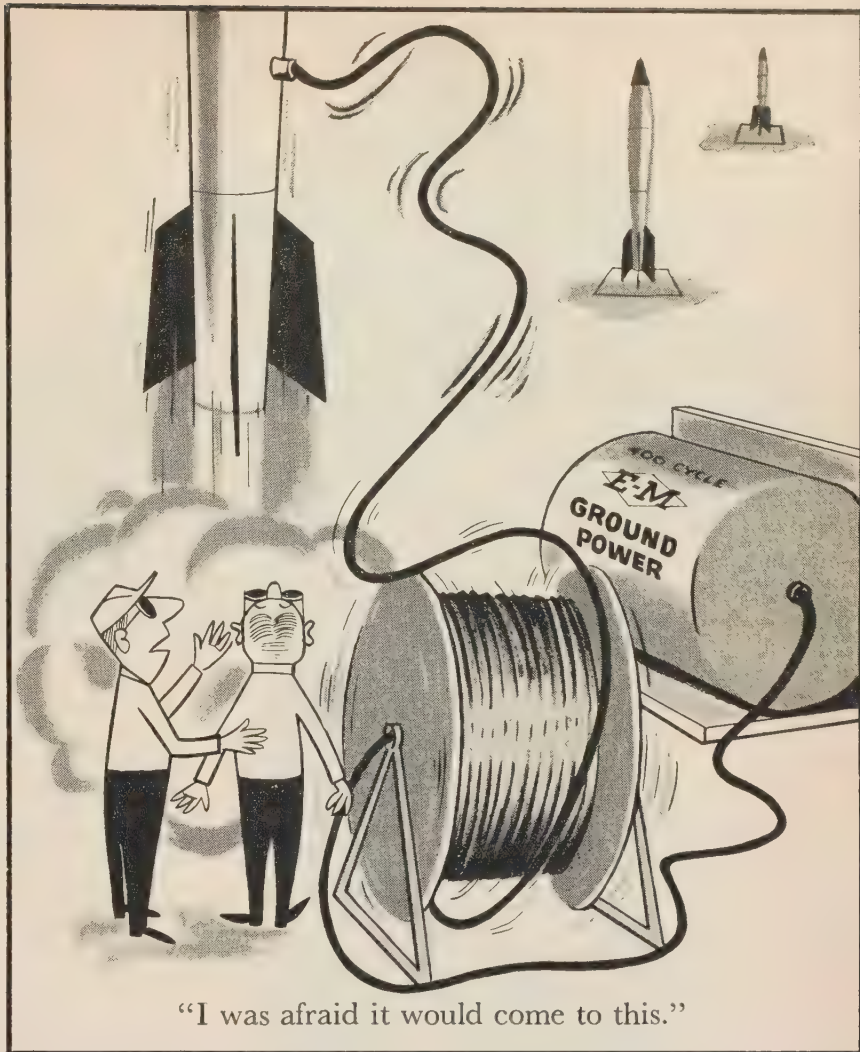
Write in No. 491 on Reader Service Card

SYSTEMS DEVELOPMENT—Bulletin 592 outlining their services in the development and production of electronic systems and equipment for government and industry is available from Strand Engineering Co., Dept. S/A, P.O. Box 76, Ann Arbor, Mich. The new bulletin illustrates and gives major features of industrial and automation systems.

Write in No. 492 on Reader Service Card

HIGH VOLTAGE TESTS—Bulletin GEA-6843 describes high voltage ac test sets, rated 50,000 to 350,000 test voltage, 5 to 1,000 kva. It has been prepared by General Electric Co., Dept. S/A, Schenectady 5, N. Y. It includes product features, characteristics and operation of mobile and stationary high potential ac test sets. There are dimensional drawings, rating and weight tables.

Write in No. 493 on Reader Service Card
more on next page

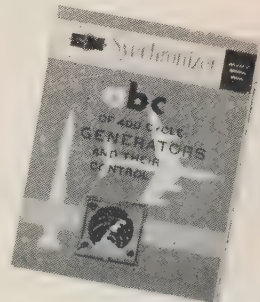


Ground Power Problems? ...Here is the Answer!

Whatever your requirements in 400 cycle ground power equipment, E-M's large staff of specialists, with unmatched 400 cycle generator experience, can help. Missiles and jet aircraft that now have the advantages of E-M's imaginative engineering of 400 cycle ground power generators include Titan, Nike-Hercules, Snark, Matador, Hound Dog, B-47, B-58, and B-52.

Designing and building 400 cycle generators to meet the exacting requirements of missile and jet applications requires a big investment in experienced, technical manpower and plant facilities. Ask your nearby E-M Field Engineer to show you his copy of "Ground Power for Space". It's an informative picture story of E-M's investment in your 400 cycle ground power needs.

FREE 28-PAGE ILLUSTRATED BOOKLET offers many answers to your 400 cycle ground power questions. Write the factory for a free copy of "ABC of 400 Cycle Generators and Their Control". It's packed with useful information about performance characteristics and mechanical construction of 400 cycle ground power generators.



ELECTRIC MACHINERY MFG. COMPANY
Minneapolis 13, Minnesota

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probing?

Need a reliable source for manufacturing your precision parts and components? The Fenn Manufacturing Company is such a source . . . with over 50 years of experience in precision manufacturing, fine engineering talent, and ultra-modern facilities. Fenn currently manufactures precision components for the aircraft and nuclear industries including helicopter main rotors and gear boxes, parts for gas turbine and jet aircraft engines, and nuclear reactor components. Entrusted with this critical work, you can be assured that Fenn has the specialized skills and know-how to meet your most rigid specifications.



*To help you to better evaluate
Fenn's ability to serve you,
send for copy of Facilities Folder*

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FENN

THE FENN MANUFACTURING COMPANY • NEWINGTON, CONN.,

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DATA PREVIEW

ABRASIVE FINISHING—Complete data on wheel heading, lubrication, speed and type of buff are included in a data sheet on abrasive finishing of aluminum and magnesium and their alloys issued by **Lea Mfg. Co., Dept. S/A, 16 Cherry Ave., Waterbury 20, Conn.** Instructions cover castings, formings, extrusions, spinnings and stampings.

Write in No. 494 on Reader Service Card

HYDRAULIC PUMP—A variable displacement, two-stage hydraulic pump for military aircraft is described in a booklet by **American Brake Shoe Co., Dept. S/A, 530 Fifth Ave., New York 36, N. Y.** It provides information on operating characteristics, installation and performance.

Write in No. 495 on Reader Service Card

ROTARY SOLENOIDS—A brochure on rotary solenoid products and systems has been issued by **Illinois Tool Works Pacsol Div., Dept. S/A, 3155 El Segundo Blvd., Hawthorne, Calif.** It describes standard and special solenoids, packaged switch assemblies and 360 deg drive stepping units. Specifications and applications are discussed.

Write in No. 496 on Reader Service Card

PHENOLICS—A reference booklet listing physical properties of 33 phenolic and 3 diallyl phthalate molding compounds has been prepared by **Hooker Chemical Corp., Dept. S/A, N. Tonawanda, N. Y.** It illustrates typical products molded from each material.

Write in No. 497 on Reader Service Card

TUBING—Analyses of tubing—columbium, tantalum, and vanadium—are contained in Memo. No. 121 published by **Superior Tube Co., Dept. S/A, 1902 Germantown Ave., Norristown, Pa.** It contains general information and discusses applications.

Write in No. 498 on Reader Service Card

TEMPERATURE CONTROLS—A catalog sheet describing surface mounting temperature controls has been issued by **Fenwal, Inc., Dept. S/A, Pleasant St., Ashland, Mass.** Catalog MC-186 provides specifications and details on 11 modifications.

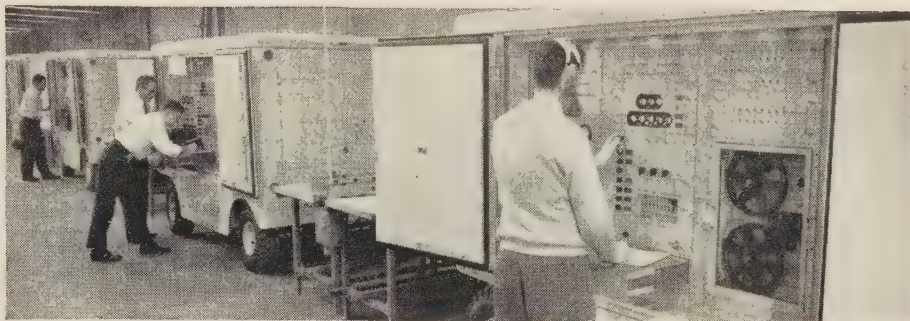
Write in No. 499 on Reader Service Card

REINFORCED PLASTICS—A collection of scientific papers on behavior of reinforced plastics at very high temperatures has been issued by **General Electric's Missile & Space Vehicle Dept., Dept. S/A, 3198 Chestnut St., Philadelphia 4, Pa.** The publication is called PIB 15 and it presents detailed theoretical and experimental results on materials investigated for a plastic suitable for protection during re-entry into the earth's atmosphere.

Write in No. 500 on Reader Service Card

more on page 322

TECHNICAL KNOWLEDGE + EXPERIENCED MANAGEMENT + SPECIALIZED CRAFTSMANSHIP = **KNOWMANSHIP**



Knowmanship tuned perfectly to ground support problems

As weapons systems become more and more complex, it becomes more and more important—and difficult — to develop effective, integrated ground support equipment. For more than fifteen years, Eclipse-Pioneer's **KNOWMANSHIP** has been responsible for developing exactly that caliber of ground support covering a wide range of applications.

Witness the Mobile Test Set that makes 750 dynamic and static tests on the B-58's flight control

system in 90 minutes. It is a product of **KNOWMANSHIP**. So is the support equipment for the Inertial Guidance Stable Platform on the Army's Pershing missile. And it is **KNOWMANSHIP** that developed Air Data Computer support



equipment that is compatible with F-101, F-104, F-105, F-106 and B-58 aircraft.

Nowhere else is specialized knowledge, management, and craftsmanship more essential to project success than in the science of developing ground support equipment. To fully explore the capabilities of **KNOWMANSHIP** on problems you may have in this area—or in any of the other areas mentioned below—call, wire, or write us today.

69% of E-P's procurement dollars go to small business.

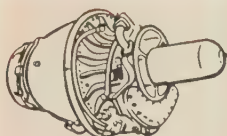
ECLIPSE-PIONEER

TETERBORO, N. J.
DIVISION of

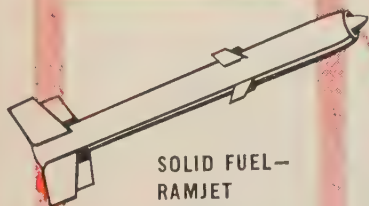


AUTOMATIC FLIGHT CONTROL • CENTRAL AIR DATA SYSTEMS • SPECIALIZED INSTRUMENTATION • NAVIGATION COMPUTERS AND DIRECTORS
STABLE PLATFORMS • INERTIAL GUIDANCE • RADAR ANTENNA STABILIZATION AND TRACKING SYSTEMS • GROUND SUPPORT EQUIPMENT

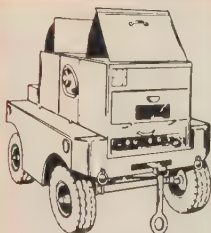
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TURBINE PROPULSION



SOLID FUEL—
RAMJET
PROPULSION



GROUND SUPPORT

CAE POWER

- Research
- Development
- Production

Continental Aviation & Engineering Corp. is exceptionally well qualified, both by experience and by facilities, for work on the weapons systems of tomorrow. Our background embraces not only a half-century of internal combustion engine experience, but also years of pioneering in gas turbine engine development, and more than a decade in the field of solid fuels for ramjet propulsion of missiles and target drones . . . Continental is staffed and equipped for a wide range of assignments, military and commercial. The Detroit Division Research and Development Department is supported by our modern-to-the-minute Component Testing Laboratory complete with environmental facilities located at Toledo. The Toledo Production Division now producing various turbine engines in volume is capable of supporting diversified programs . . . The CAE record of achievement is one of which many a larger company might be proud. Inquiries are invited from those having propulsion problems, on the ground, on the water, in the air.



CONTINENTAL AVIATION & ENGINEERING CORPORATION

GENERAL OFFICES AND RESEARCH AND DEVELOPMENT DEPARTMENTS AT 12700 KERCHEVAL AVENUE, DETROIT 15, MICHIGAN . . . PRODUCTION DIVISION AND FIELD SUPPORT, 1330 LASKEY ROAD, TOLEDO, OHIO.

SUBSIDIARY OF CONTINENTAL MOTORS CORPORATION

Write in No. 402 on Reader Service Card at start of Product Preview Section

DATA PREVIEW

MEASURING TOOLS—A catalog of measuring tools, specialties, optical measuring equipment, gear hobbing and testing machinery has been prepared by Scherr-Tumico, Dept. S/A, 200 Lafayette St., New York 12, N. Y. It contains 96 pages and is illustrated.

Write in No. 501 on Reader Service Card

TUBE FITTINGS—A flange adapter unit for instrument panels is described in a data sheet by Crawford Fitting Co., Dept. S/A, 884, E. 140 St., Cleveland, Ohio. The sheet is illustrated.

Write in No. 502 on Reader Service Card

TITANIUM ALLOY—Heat-treatable titanium alloy, Ti-4Al-3Mo-IV is the subject of an engineering bulletin by Titanium Metals Corp., of America, Dept. S/A, 233 Broadway, New York 7, N. Y. It covers physical, mechanical and design properties.

Write in No. 503 on Reader Service Card

GROUND SUPPORT EQUIPMENT—Ground support equipment systems, components and capabilities for aircraft and missiles are discussed in a brochure prepared by Lear, Inc., Dept. S/A, P. O. Box 688, Grand Rapids 2, Mich. The brochure is called GR-317.

Write in No. 504 on Reader Service Card

AXIAL PISTON PUMPS—Bulletin No. A 5232 contains complete details on 5000 psi axial piston pump, model A-12900 series, issued by Vickers, Inc., Dept. S/A, Detroit 32, Mich. Contained are capacity data, size, weight, horsepower, horsepower weight ratio, control features and other design characteristics.

Write in No. 505 on Reader Service Card

CONNECTORS—A catalog sheet describing high temperature connectors has been issued by Harco Laboratories, Dept. S/A, 77 Olive St., New Haven 7, Conn. It discusses applications and gives complete information on sizes, types, contact patterns, MS cross reference numbers and insert data.

Write in No. 506 on Reader Service Card

DIGITAL VOLTMETERS—Its series 30 digital voltmeters for measurement of ac and dc voltages and voltage ratios is described in a bulletin by Non-Linear Systems, Inc., Dept. S/A, Del Mar, Calif. It discusses the four-digit V34 and five-digit V35, including explanations of transistorized "no-needless-nines" logic, specifications, operating information, input and output accessories, conversions for ac measurements, wiring diagrams for designing the instruments into data logging and measurements systems.

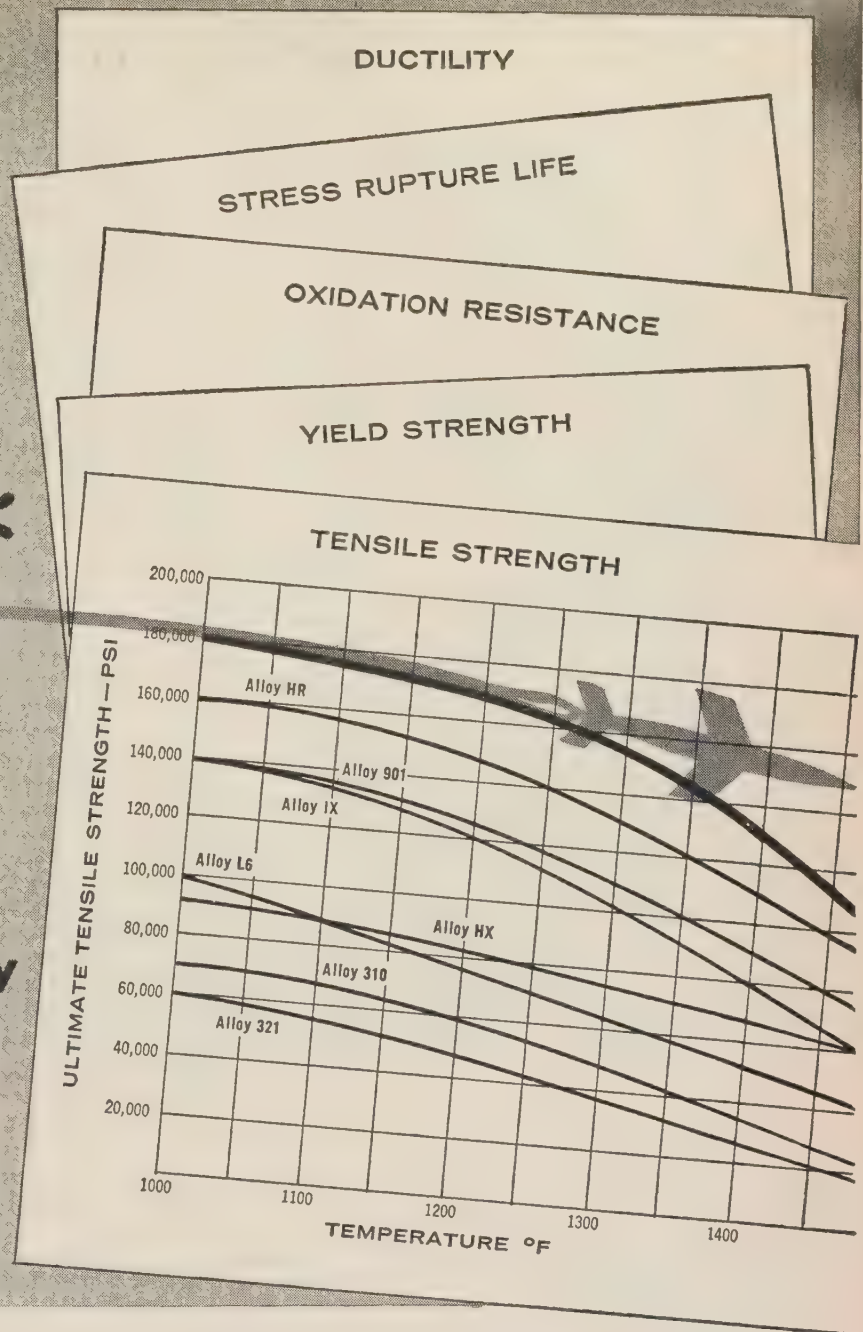
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more on page 326

SPACE/AERONAUTICS

HIGH on every chart: RENÉ 41*

most
dependable alloy
in use today
in the
1200°- 1800°F
range



In *all* ways, René 41 is a remarkable alloy. No other high-temperature alloy used in production today equals its tensile strength. In other properties, too, René 41 is far ahead of the field.

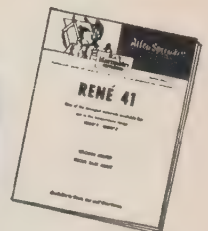
Also important, this nickel-base, vacuum-melted alloy is easy to work with. It's readily formable by drawing, bending, spinning — welds to similar or dissimilar materials.

Cannon-Muskegon offers René 41 in standard 36"x 96" sheets .015" to .125" thick, in smaller sizes down to .010", in bar stock up to 3" in diameter...

foil down to .001 in thickness... and fine wire only .0015 in diameter.

For complete details, write for Technical bulletin No. 86.

*TM of General Electric Co.

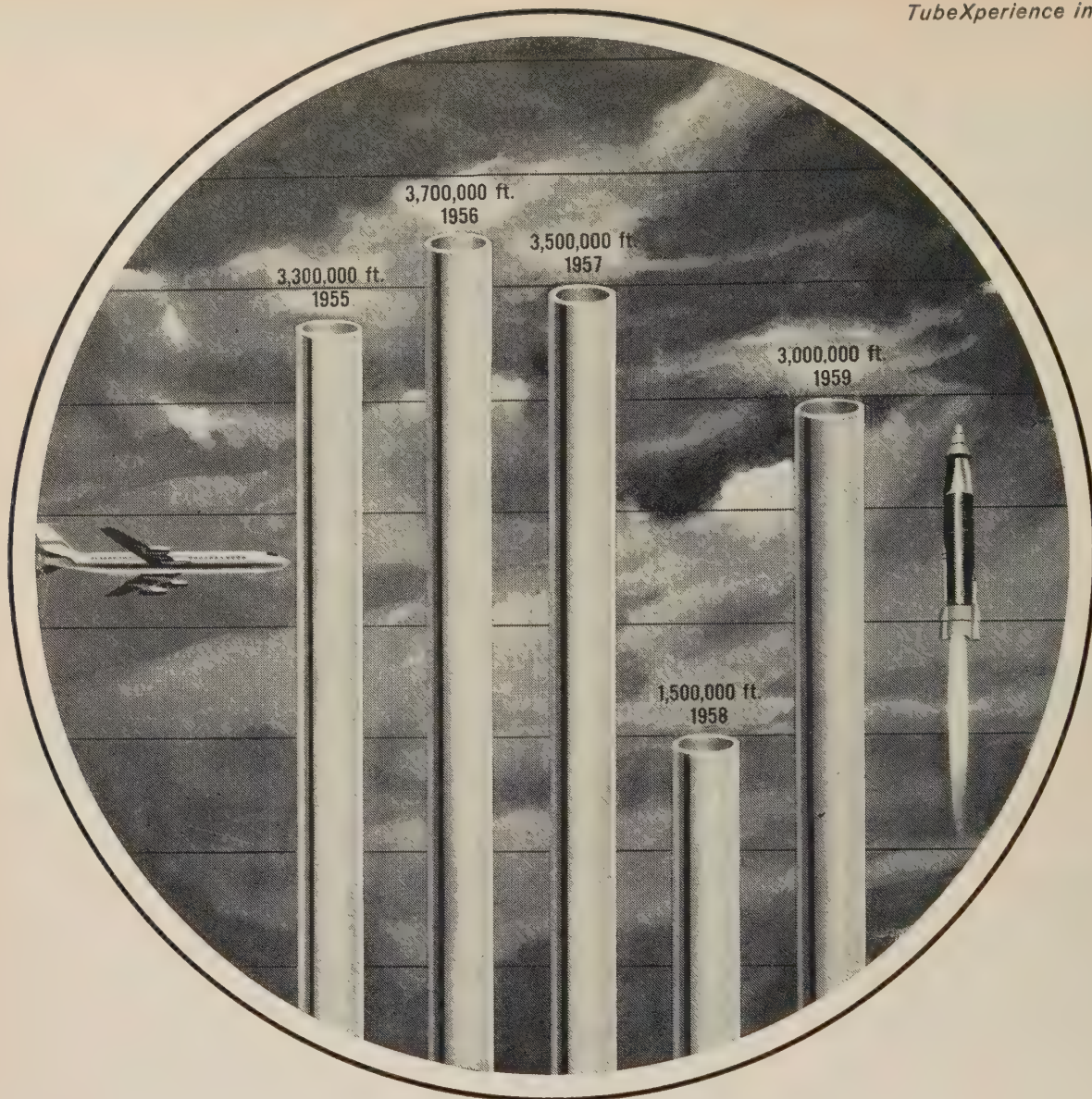


CANNON-MUSKEGON CORPORATION

2887 Lincoln Avenue • Muskegon, Michigan

METALLURGICAL SPECIALISTS

Write in No. 403 on Reader Service Card at start of Product Preview Section



Over 15,000,000 ft. of Superior stainless hydraulic tubing helps today's aircraft and missiles to operate efficiently

In the past 5 years more than 15,000,000 ft. of Superior stainless steel aircraft hydraulic tubing has been produced for use in military, commercial and private aircraft.

Here are some of the steps taken by Superior to make certain its aircraft quality hydraulic tubing not only meets specifications, but saves time and money by eliminating rejects and provides long, trouble-free service life.

Before material is released for production, it is metallographically checked for grain size and characteristics. A chemical analysis is made, and wall runoff is checked. Samples are pickled and checked for carburization. In production, intermediate annealing operations are 100% automatically controlled. Checks are made for metallic chips and other

foreign matter. Then, as a final inspection, all tubing is 100% hydrostatically and flare tested. We now produce to 18 current MIL, AMS and AN Specifications—and can supply many extras far above normal specifications.

If you have a problem involving aircraft quality tubing and want the best combination of physical and mechanical properties, including high strength, ductility, fatigue and corrosion resistance, and good working qualities, consult us. We specialize in Seamless and WELDRAWN® stainless steel hydraulic tubing in AISI Types 304, 321 and 347 and in sizes from .012 through 1.125 in. OD. Send for Catalog 21 on stainless steel tubing. Superior Tube Company, 2038 Germantown Ave., Norristown, Pa.

Superior Tube

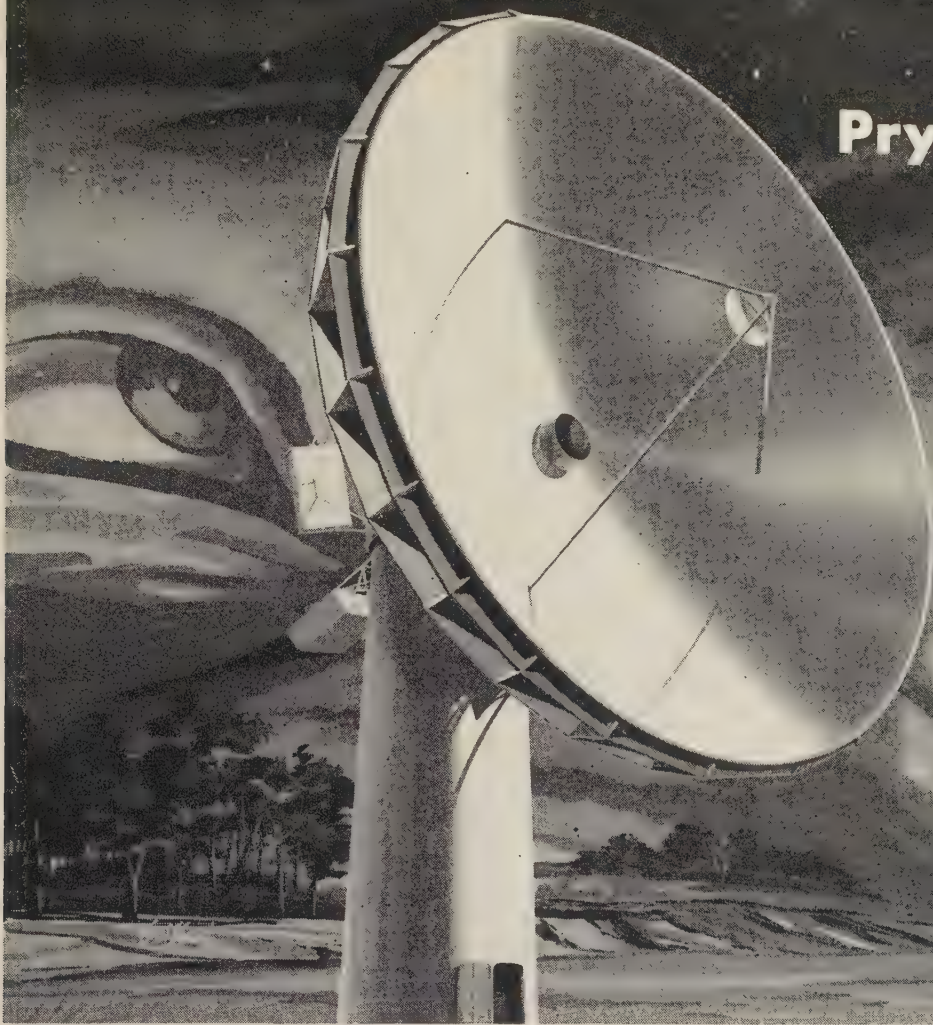
The big name in small tubing
NORRISTOWN, PA.

All analyses .010 in. to $\frac{3}{8}$ in. OD—certain analyses in light walls up to $2\frac{1}{2}$ in. OD

West Coast: Pacific Tube Company, Los Angeles, California • FIRST STEEL TUBE MILL IN THE WEST

Write in No. 404 on Reader Service Card at start of Product Preview Section

Prying saucer!



AERONCA designs and produces precision antenna systems for advanced radar complexes

Featuring new concepts in design and construction, Aeronca paraboloid antennas set new standards in precision . . . regardless of size. The principles and accuracy inherent in the 60-foot X-Band dish illustrated above are adaptable to antenna designs of virtually any size or shape.

Aeronca antennas are lightweight high-strength rigid structures of honeycomb sandwich construction. Developed by integrated design-tool-produce capabilities, they are fabricated by advanced techniques that substantially reduce tooling requirements . . . simplify unit design . . . assure low-cost producibility. In addition, Aeronca antennas permit lighter support structures and mechanisms because they weigh 40% to 60% less than conventional designs.

Whatever your antenna problems, Aeronca can supply "packaged" capabilities to meet your requirements and specifications. For details, write for BULLETIN AR-201.

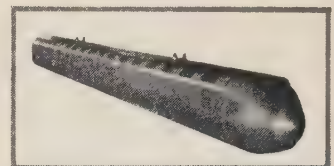


AERONCA

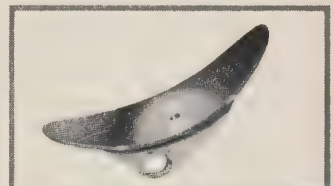
manufacturing corporation
1724 Germantown Road
Middletown, Ohio

Openings for creative R&D Engineers with Missile-Space experience. Write to O. E. Chandler, Mgr. Professional Employment.

IN DIAMETERS UP TO 300', Aeronca antennas provide unparalleled accuracy at frequencies of X-Band and higher.



APS-94 ANTENNA SYSTEM included complete design of antenna for airborne side-looking radar.



B-58 BOM-NAV SYSTEM reflectors feature curvature tolerances of $\pm .005''$.

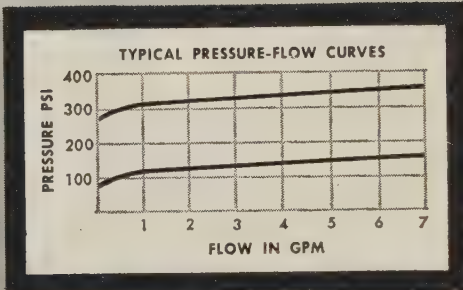
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*For Precise
Control of
Pressurized
Fluids...*



Another **NEW** Cartridge **RELIEF VALVE**

- Eliminates connectors, fittings and lines
- Reduces leakage points
- Simplifies maintenance
- Reliable
- Noiseless



■ Simplified circuitry, reduced weight, and greater design freedom are other advantages offered by this direct acting relief valve. Now used in ground handling equipment, this valve is installed in a multi-valve manifold and can be removed without disconnecting any lines. This precision valve is just one of many fluid flow and pressure control valves Fluid Regulators has designed and manufactured to meet exacting specifications. Our experienced, specialized engineers are always available to discuss and aid you with your specific problem. Just call or write:

*Designers and manufacturers of
hydraulic and fuel valves for
aircraft, missiles, rockets, ground
handling and support equipment.*

SPECIFICATIONS

- Operating Pressure: Three ranges 75 - 500 psi
- Burst Pressure: Above 5,000 psi
- Cracking Pressure: Externally adjustable
- Internal Leakage: Drops per minute
- External Leakage: Zero
- Fluids: All fluids compatible with stainless steel and anodized aluminum
- Temperature: -65° F. to $+275^{\circ}$ F.
- Weight: 6 oz.
- Part No.: 7385

This valve can be furnished with a body and to meet user's pressure and flow requirements.

**Fluid
R**egulators
CORPORATION

313 Gillette Street • Painesville, Ohio • Elmwood 2-3319

DATA PREVIEW

PRE-HARDENED STEEL—A technical bulletin on engineering and maintenance applications of a pre-hardened, machinable high strength steel, called Viscount 44, has been prepared by Latrobe Steel Co., Dept. S/A, Latrobe, Pa. The bulletin contains a tempering curve for lower hardness.

Write in No. 508 on Reader Service Card

PRODUCTION CHEMICALS—A production information digest discussing the characteristics of a number of compounds has been issued by Callery Chemical Co., Dept. S/A, 201 N. Braddock Ave., Pittsburgh 8, Pa. It contains a table of the physical properties and suggests uses for each.

Write in No. 509 on Reader Service Card

NUCLEAR MAGNETIC RESONANCE—Material Study Report No. 29.58 on model 104 Nuclear Magnetic Resonance has been issued by Schlumberger Well Surveying Corp., Instrumentation Div., Dept. S/A, Ridgefield, Conn. The report shows the results obtained and calibration curves.

Write in No. 510 on Reader Service Card

SERVO BREADBOARD—Catalog 2 is a 12-page brochure describing a servo breadboarding system developed by Gap Instrument Corp., Dept. S/A, 116 Merrick Rd., Freeport, L.I., N.Y. Heart of the system, which requires only a rough schematic for complete production in a very short time, are equally spaced gear centers, established by pairs of very accurately bored plates, and the system uses 72-pitch gears or gears whose pitch is a multiple of 24.

Write in No. 511 on Reader Service Card

VIBRATION MOUNTS—An eight-page brochure on its complete line of vibration mounts has been offered by Rexon Mount Div., Hamilton Kent Mfg. Co., Dept. S/A, Kent O. Engineering details, performance data, and installation information are included for the mounts, which are made for weights up to 20,000 lbs.

Write in No. 512 on Reader Service Card

SEALS—Pressure lock seals available in a wide range of materials and suitable for use in any static condition are the subject of a four-page brochure issued by Koppers Co., Inc., Dept. S/A, P.O. Box 298, Baltimore 3, Md. The publication discusses sealing requirements in the aircraft and other industries.

Write in No. 513 on Reader Service Card

WELDING—A pocket guide on air-comatic welding has been issued by Air Reduction Co., Inc., Dept. S/A, 150 E. 42 St., New York 17, N. Y. Form ADC 873A covers latest information on gas-shielded metal-arc welding wires.

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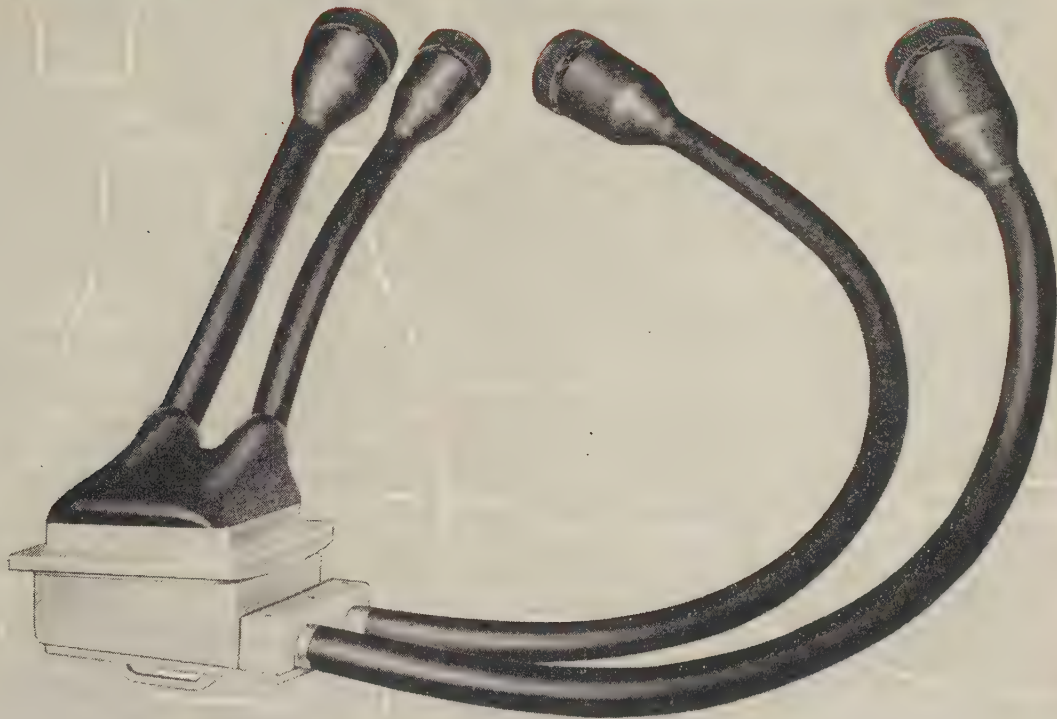
more on page 328

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for an extension in Reliability

engineered...

CANNON PLUG/HARNESS SYSTEMS



SINGLE RESPONSIBILITY FOR PERFORMANCE OF PLUG/HARNESS SYSTEMS...RELIABILITY GUARANTEED!

■ **CANNON PLUG/HARNESS SYSTEMS** are designed and manufactured under rigid, quality-controlled conditions in a separate, highly specialized facility completely equipped to handle all phases of design, development and manufacture. As a single source supplier for both plugs and harness assemblies, Cannon can assume complete responsibility for the reliability of the "Cannon Plug/Harness System" as a whole.

■ **COMPLETE TESTING FACILITIES:** Extensive testing equipment is also available to duplicate environmental conditions. These include vibration tests, temperature cycling tests, and heat flux tests duplicating heat re-entry conditions. Each system is 100% tested for continuity and for high potential and insulation resistance, shorts or grounds as well as humidity, VSWR, contact retention, etc. Certified test reports are available.

■ **SPECIAL DESIGN SERVICES:** Because Cannon is a single source supplier of the plugs and completes the termination, it is possible to select and recommend cables and termination techniques designed to custom-match the proper plug for the assembly. The complete assembly can thus be manufactured and tested under conditions prohibited to single-source suppliers.

■ **FASTER DELIVERY — NO COST PYRAMIDING:** A special, separate facility devoted to umbilical and harnessing production offers the most up-to-date production techniques to provide the industry's fastest delivery—plus no pyramiding of costs. Customers draw on Cannon's capabilities as the world's largest exclusive manufacturer of electrical plugs.

■ **FIELD TECHNICAL ASSISTANCE:** Experienced specialized sales engineers are available to discuss and assist customers in the technical aspects of plug-harness system requirements prior to manufacture and after installation in the field.

FOR FURTHER INFORMATION on Cannon Plug/Harness Systems write for Cannon Catalog HC-1—Cannon Electric Company, 3208 Humboldt Street, Los Angeles 31, Calif.

*CANNON ELECTRIC COMPANY
—Factories in Los Angeles, Santa Ana, Salem, Toronto, London, Paris, Melbourne and Tokyo.*

Distributors and Representatives in principal cities of the world.

**CANNON
PLUGS**

Write in No. 407 on Reader Service Card at start of Product Preview Section

SECTION MANAGER

Advanced Systems Planning of Missiles

SALARY:
\$18,000 LEVEL

Section Manager needed for advanced systems planning of: tactical systems, defense systems, and space systems. Will advise and direct a group of engineers responsible for establishing the probable parameters of systems, as they affect, or are affected by, electronic considerations. Must have ability to plan weapon systems without established operational requirements, assessing prospective needs or trends, and analyzing suitability of requirements and concepts.

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Box #311, Space/Aeronautics

DATA PREVIEW

ALUMINUM ALLOYS—A technical brochure outlining the properties of aluminum alloys in pig, ingot and billet forms has been prepared by Henning Bros. & Smith, Inc., Dept. S/A, 91-127 Scott Ave., Brooklyn, N. Y. Typical physical properties are given in chart form.

Write in No. 515 on Reader Service Card

FILTER ELEMENTS—Applications and characteristics of the Series 2200 Microbon ribbon fluid filter elements, which are rated for 40-micron filtration, are described in the four-page Brochure 44 by Bendix Filter Div., Bendix Aviation Corp., Dept. S/A, 434 W. 12 Mile Rd., Madison Heights, Mich. Drawings, curves and tables are used in the discussion of the application of the elements in hydraulic oil, gasoline, air, water, and other liquids and gases.

Write in No. 516 on Reader Service Card

WELDERS—Bulletin W-158 giving condensed specifications of transformers, rectifier and rotary dc welders has been prepared by Harnischfeger Corp., Dept. S/A, 4400 W. National Ave., Milwaukee 4, Wis. It contains illustrations, diagrams, and

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more on page 330



TELEFLIGHT[®] MODEL 180 AIRBORNE PRESSURE TRANSDUCER

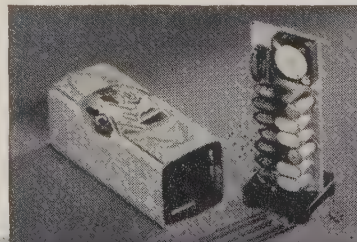
Approximately 3½" long and 10 ounces in weight. The rugged construction of Model 180 makes it the ideal Transducer for airborne applications. BONDED STRAIN GAGE construction results in low sensitivity to vibration or shock in any axis. Proving ring acts as a heat-sink for the strain gages under zero gravity conditions. Resolution is INFINITE. Features standard built-in pressure overload protection. Pressure Ranges: 0-350, 0-750 and 0-1,000 PSI. Linearity 0.25%, Hysteresis 0.25% of F.S. at any given point, Ambient Temperature -100° F. to +275° F.

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- Cross-Axis Sensitivity: 0.005 G per G maximum
- Shock: to 60 G
- Vibration: 10 G to 2000 cps
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- Weight: 1.2 lbs. maximum



TYPE LA-700

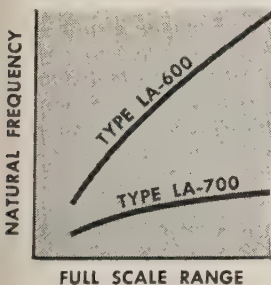
shown actual size

- Full Scale Range: ± 1 to ± 60 G
- Full Scale Output: to 25 volts
- Threshold-Resolution: 0.0001 G
- Damping Ratio: 0.6 at 25°C typical
- Natural Frequency: 5 to 30 cps
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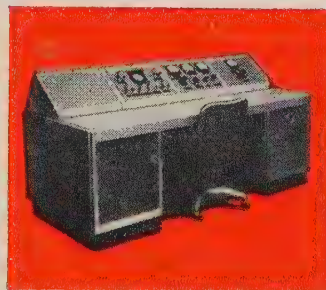
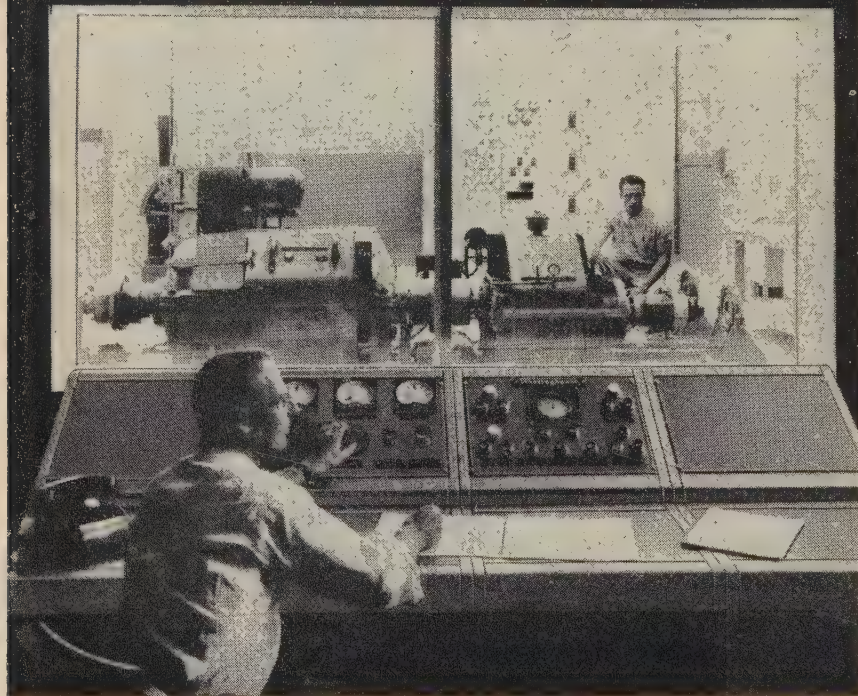


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DATA PREVIEW

FUEL PUMPS—Fixed displacement balanced vane type fuel pumps for jet engines are described in bulletin A5242 by Vickers, Inc., Dept. S/A, Detroit 32, Mich. Design and performance characteristics, a chart of delivery rates, speeds, and physical characteristics are included.

Write in No. 518 on Reader Service Card

POWER SUPPLIES—A bulletin describing transistorized power supplies has been issued by Mid-Eastern Electronics, Inc., Dept. S/A, 32 Commerce St., Springfield, N. J. It contains complete specifications.

Write in No. 519 on Reader Service Card

BUTTERFLY VALVES—Bulletin 50-1 is a condensed bulletin covering the complete line of butterfly valves made by Continental Equipment Co., Dept. S/A, Coraopolis, Pa. Eight designs, some with pressure drops up to 1200 psi and temperature ranges to 2000 deg F, are presented in tabular form.

Write in No. 520 on Reader Service Card

INDICATOR LIGHTS—Form L-162, a four-page brochure on two-terminal subminiature indicator lights designed to mount from the front of a panel in a 1 1/2-in. clearance hole, is available from Dialight Corp., Dept. S/A, 60 Stewart Ave., Brooklyn 37, N.Y. Neon, incandescent, water-tight, and edge-lighting types are discussed.

Write in No. 521 on Reader Service Card

METEOROLOGICAL SOUNDING—"Roksonde, A Practical 200,000-ft Meteorological Sounding System," is a 20-page paper available from Cooper Development Corp., Dept. S/A, 2626 S. Peck Rd., Monrovia, Calif. System components, performance data, and operational procedures are among the areas considered.

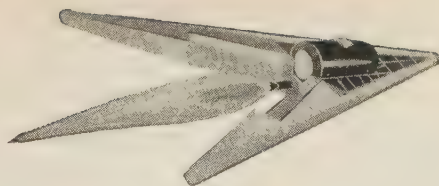
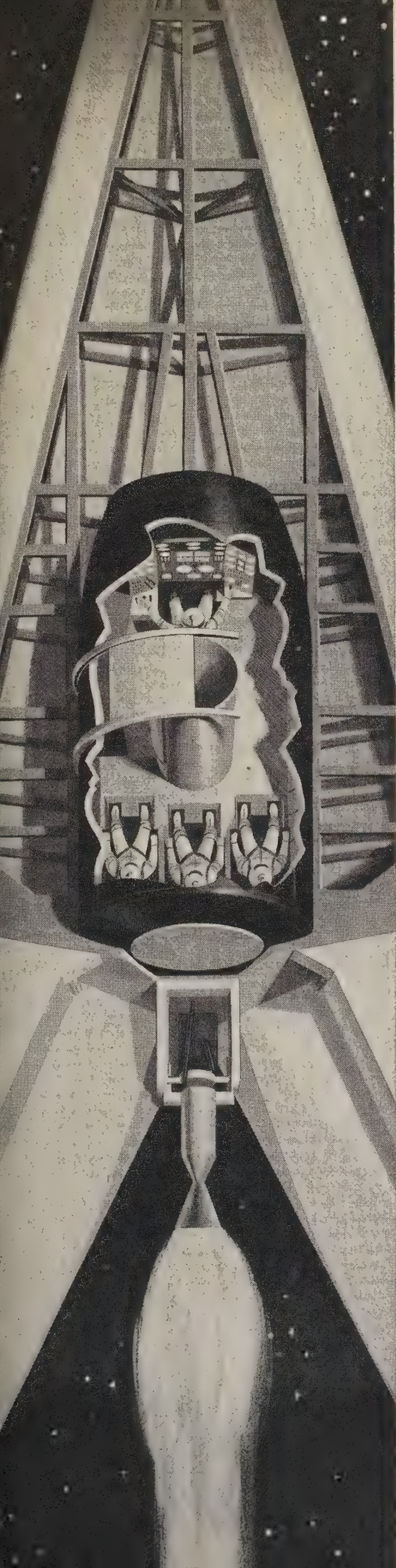
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NULL METER—Features, application, circuitry and specifications of a dc voltage standard and null meter are discussed in Bulletin 15-7, available from Kin Tel Div., Cohu Electronics, Dept. S/A, 5725 Kearny Villa Rd., San Diego 12, Calif. The Model 301 meter can be used to measure dc in the range of one to 501 V full scale.

Write in No. 523 on Reader Service Card

PRESSURE PICKUP—The 4-380A potentiometer pressure pickup for missile use is the subject of Bulletin 1604, an information sheet prepared by Consolidated Electro-dynamics Corp., Dept. S/A, 360 Sierra Madre Villa, Pasadena, Calif. Design features and specifications are presented, along with a general description.

Write in No. 524 on Reader Service Card
more on page 332

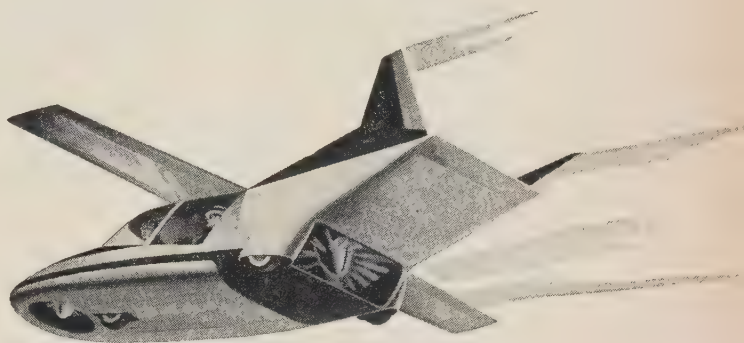


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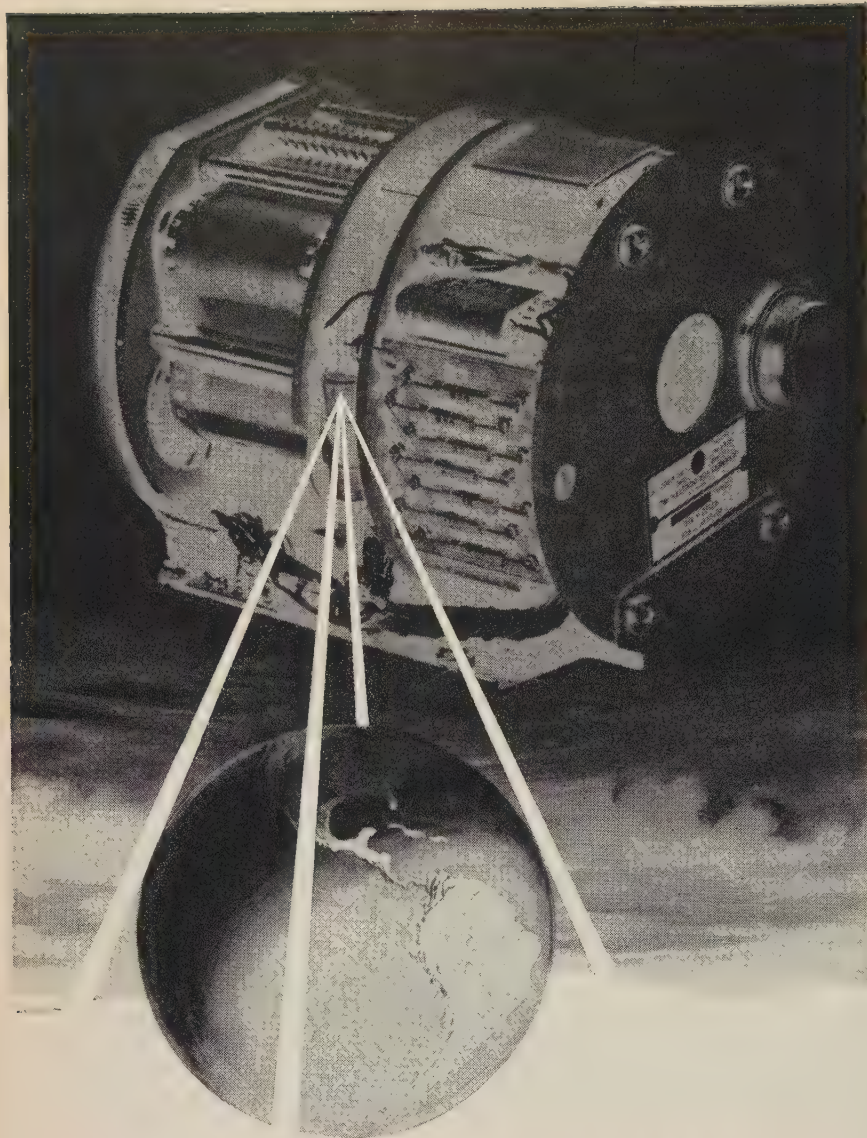


High-caliber scientists and engineers are invited to explore Lockheed's long-range plans—future projects that offer great rewards for men of great promise. Openings are available in: Aero-thermodynamics; electronics—research, systems; flight test instrumentation; servosystems and flight controls; experimental physics; astro-physics; bio-physics. Please address your inquiry to: Mr. E. W. Des Lauriers, Manager Professional Placement Staff, Dept. 1904, 2401 N. Hollywood Way, Burbank, California.

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DATA PREVIEW

STEEL—A booklet on a high strength steel for use in aircraft, missiles and rockets has been issued by Allegheny Ludlum Steel Corp., Dept. S/A, Oliver Bldg., Pittsburgh 22, Pa. It contains graphs and charts.

Write in No. 525 on Reader Service Card

FLOWMETER—A true-mass flowmeter that is designed to operate satisfactorily for 1000 hrs has been described in a data sheet by Gloster Aircraft Co., Ltd., Dept. S/A, Gloucester, England. Range of the eight-lb system is zero to 300 lbs/min.

Write in No. 526 on Reader Service Card

TELEMETRY TESTING—Test facilities primarily used for reliability and performance checks of telemetry equipment but useful in other testing applications have been described in Bulletin 859 by Tele-Dynamics, Inc., Dept. S/A, 5000 Parkside Ave., Philadelphia 31, Pa. Among the tests possible are those for vibration, humidity, altitude, acoustical noise, and radio interference.

Write in No. 527 on Reader Service Card

ROTARY SWITCH—A data sheet on a versatile, high-precision, rotary switch has been issued by Waters Mfg., Inc., Dept. S/A, Wayland, Mass. During each revolution the WP-2 can provide momentary contact as desired or close a circuit for a required time, and it can also provide pulses, spaced as required, for almost any desired duration.

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CRYOGENIC PUMP—The Series 2000 medium-pressure petrochemical and cryogenic transfer pump is the subject of a catalog sheet available from Turbocraft, Inc., Dept. S/A, 492 E. Union St., Pasadena, Calif. The lightweight, operationally flexible pump can be furnished with almost any type of drive.

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CONNECTORS—A four-page brochure designed to aid users in the selection of Cannon ms E/R connectors conforming to Mil-C-5015C and Mil-C-5015D is available from Schweber Electronics, Dept. S/A, 60 Herricks Rd., Mineola, L.I., N.Y. The brochure presents a complete listing of available units by insert arrangement and number of connector.

Write in No. 530 on Reader Service Card

INVERTER—AIC 1028 is an information sheet on a dc-ac inverter developed for airborne timing and control applications by Abrams Instrument Corp., Dept. S/A, Lansing, Mich. The 400-cycle synchronous motor power supply has an accuracy of .025 per cent, reduces radio noise filtering problems, provides and maintenance-free motor life.

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more on page 334

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velocity, target position, barometric pressure, and other data into information for surface to surface missile firings. The soldier-technician monitoring the exchange of computer data will have modularized communications with the other elements of his tactical organization. RCA is the leader contractor of this important United States Army Signal Corps program and is working in close harmony with the electronic components industry.



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DATA PREVIEW

SUPERALLOYS—Technical bulletins covering performance data on vacuum induction melted Udimet 700 and 41 superalloys have been issued by the Kelsey Hayes Co., Metals Div., Dept. S/A, New Hartford, N. Y. Included are alloy description, chemical composition, physical constants, tables and charts on mechanical properties, iso-stress curves, and information on heat treatment and finishing.

Write in No. 532 on Reader Service Card

POWER SUPPLIES—Ac/dc power supplies and dc/dc converters useful in guidance, flight control, computer, missile checkout, radar and other airborne and ground applications are briefly considered in the six-page Bulletin 102, available from Arnoux Corp., Dept. S/A, 11924 W. Washington Blvd., Los Angeles 66, Calif. The bulletin also compares the basic operation of transistor and magnetic-amplifier regulated power supplies.

Write in No. 533 on Reader Service Card

NOISE GENERATOR—A noise generator for use in acoustic testing of missiles and aircraft components has been described in a four-page bulletin available from Avco Research and Advanced Development Div., Dept. S/A, 201 Lowell St., Wilmington, Mass. The generator uses an electro-mechanical transducer of the moving coil type to produce 166 db of random noise and 170 db at discrete frequencies.

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INJECTION PUMP—The performance and specifications of the Model 188 water injection pump are considered in a catalog sheet available from Santa Barbara Div., Curtiss-Wright Corp., Dept. S/A, 6767 Hollister Ave., Goleta, Calif. The pump, designed for use with turbojet engines, can be driven hydraulically or adapted to turbine, electric-motor or engine accessory pad drive.

Write in No. 535 on Reader Service Card

VALVE SELECTION—"How to Specify Solenoid Valves" is an eight-page booklet available from Valcor Engineering Corp., Dept. S/A, 365 Carnegie Ave., Kenilworth, N.J. Sections are included on valve sealing, mechanical, electrical and environmental specification criteria, and nomenclature.

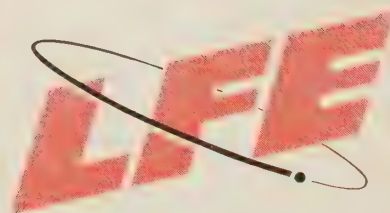
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VARNISHES—The selection and application of electrical insulating varnishes have been covered in a 35-page catalog available from Irvington Div., Minnesota Mining and Mfg. Co., Dept. S/A, 900 Bush Ave., St. Paul 6, Minn. Properties, testing procedures, baking and curing, storing and handling, and solvents are among the topics considered.

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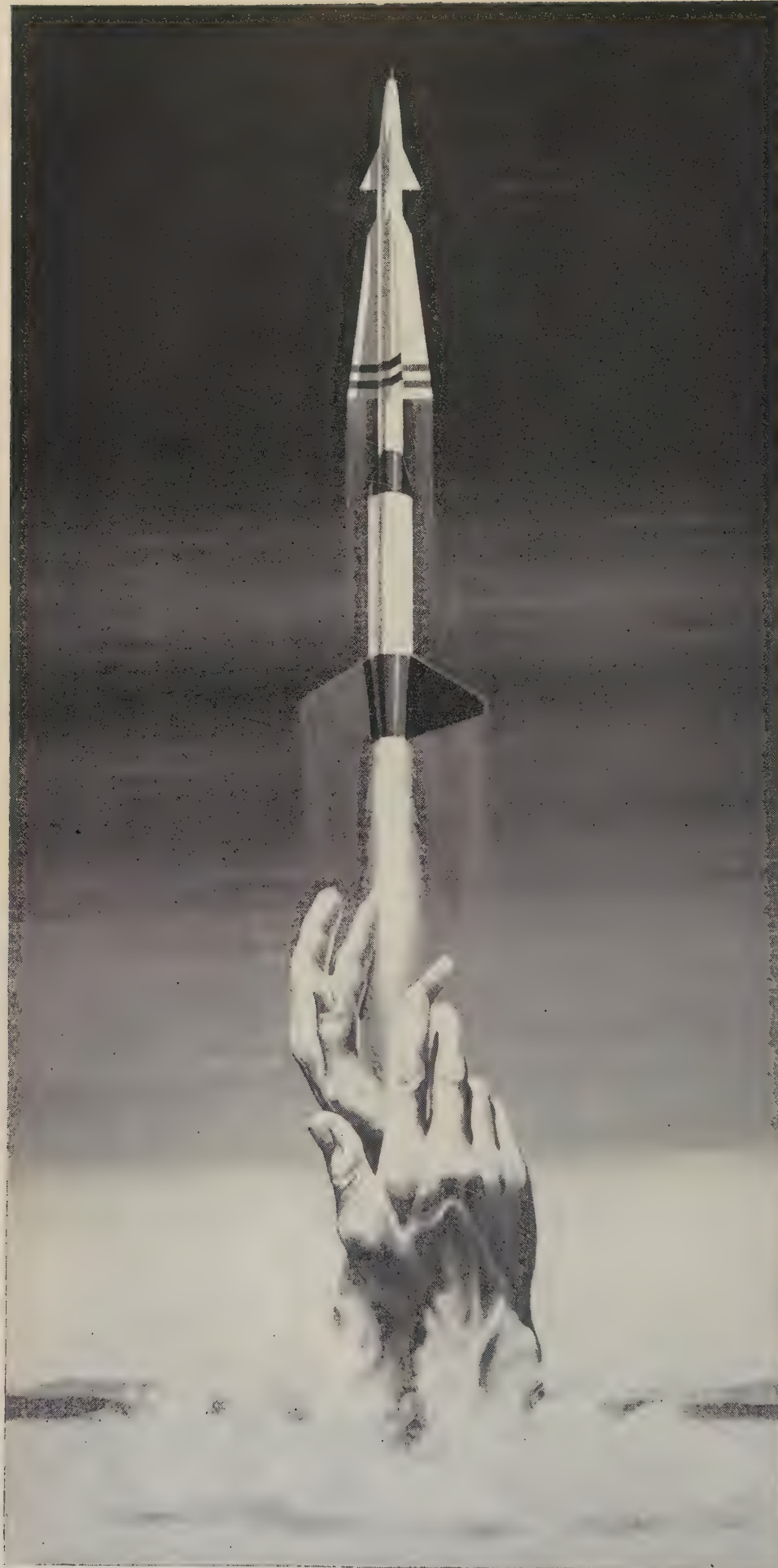
Further details about LFE Storage Systems may be had by writing the Vice President of Marketing. Ask for Technical Data Digest No. 6032.



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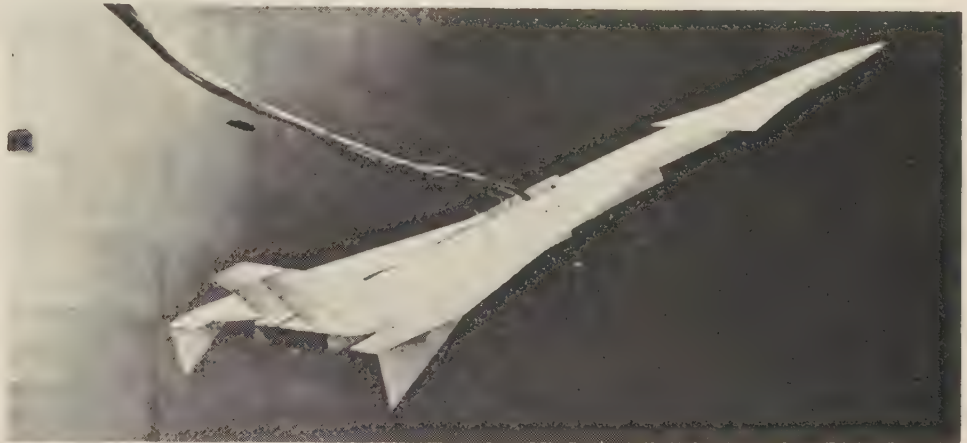
*18 PLANTS: Detroit and Jackson, Michigan;
Los Angeles; Philadelphia and McKeesport,
Pennsylvania; Springfield, Ohio; New Hartford
and Utica, New York; Davenport, Iowa;
Windsor, Ontario, Canada.*



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SPACE/AERONAUTICS

B-70 MODEL photo attributed to NASA was published by Steelways magazine. After a series of cancellations, the North American bomber now is just about a dead design.



FULL-SCALE MOCKUP of the Army's new twin-turbine Vertol YHC-1B Chinook copter with an H-21C in the background. Although one foot shorter than the operational H-21C, the Chinook has almost three times more room in its cargo compartment. Engines are Lycoming YT55s.

MAIN TUNNEL of a hardened underground Titan base under construction. It will lead from the control center to the silo launching emplacement.



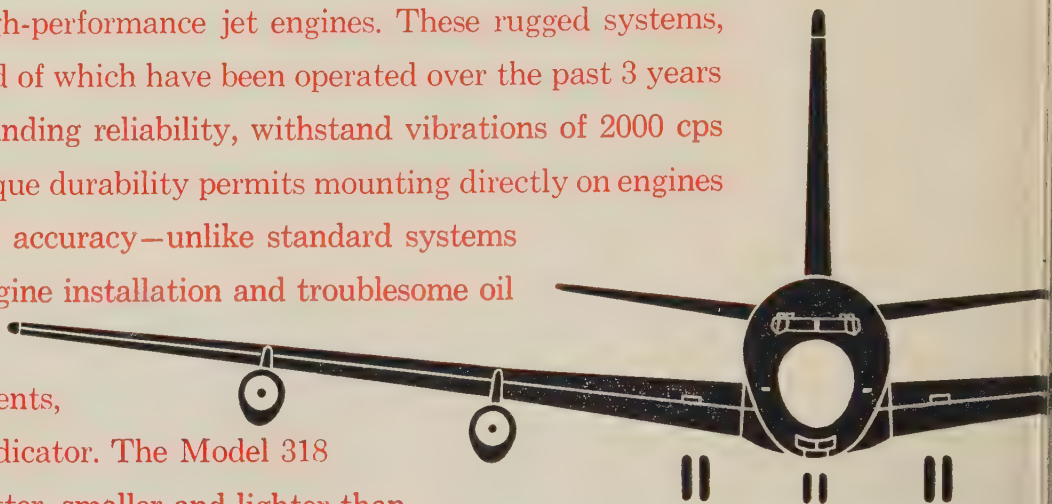
American Bosch Arma bought Tele-Dynamics of Philadelphia and will operate it as a separate, 450-employee division. Tele-Dynamics has worked on airborne transmitting and ground receiving and recording equipment.

General Electric entered the information systems field through its Defense Electronics Division, Dr. G. L. Haller, GE vice president and general manager of the division, announced. The Division will work on military and business information systems at Bethesda, Md.

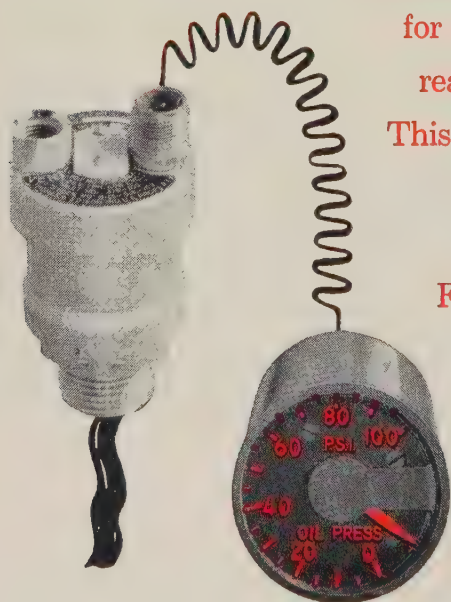
Giannini Scientific, of New York City, acquired Flight Research, of Richmond, Va. Flight Research specializes in the design and manufacture of photographic instrumentation and produces a variety of aircraft accessories.

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ever before, meets requirements of new specification MIL-T-26638. Hermetically sealed indicators, available in 1½" and 2", require less than 0.6 watts for operation. A 2" model is integrally lighted for utmost readability in compliance with MIL-L-25467A (ASG). This versatile indicating system—originally designed for oil pressure measurement—can also be used to indicate fuel pressure, BMEP, as well as torque. For the full story on aviation's most reliable pressure indicating system, write for publication 3049.



Standard hermetically sealed indicator, available in 1½" and 2". Model 296, a 2" indicator, is integrally lighted: in daylight, numerals and pointer are white and at night red. When power is off, pointer will move off-scale below zero.

Thomas A. Edison Industries

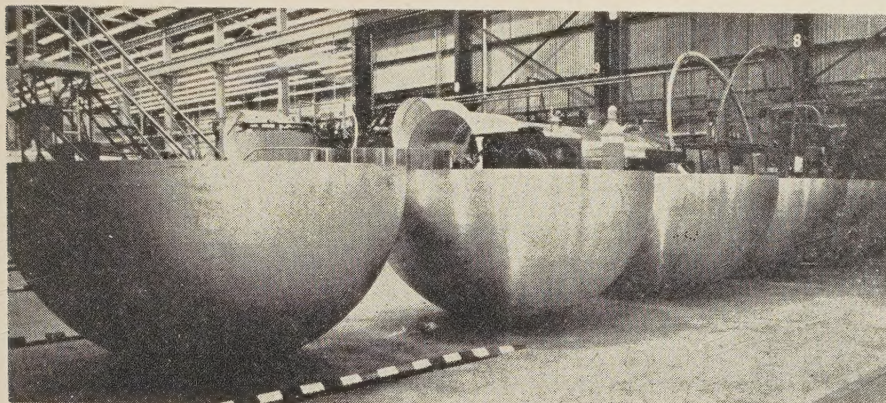
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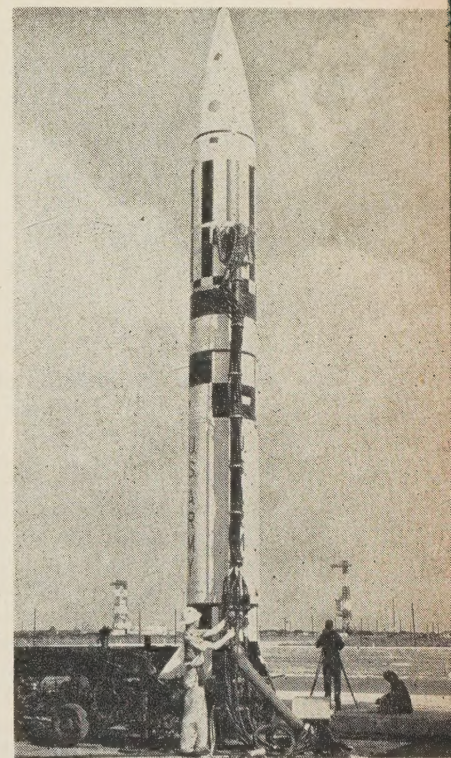
SPACE/AERONAUTICS



SPUN BULKHEADS for the Saturn booster in the fabrication and assembly lab at Redstone Arsenal, Huntsville, Ala. Made of 5456 aluminum by Alcoa, the bulkheads will be used for the 70-in.-diameter fuel and LOX tanks clustered around the 105-in.-diameter center tank.



MORE THAN 60 successful parachute drop tests are reported for the B-70's capsule seat by NAA. If a B-70 must be abandoned, each crew member's seat is turned into an airtight ejection capsule—clam-type doors snap shut from top and bottom.



PERSHING on its new transporter-erector-launcher, with which the Martin solid propellant IRBM can be emplaced, erected, and launched in a matter of minutes.

Chance Vought expanded into the automation field by buying an 80 per cent interest in Information Systems, Inc., of Skokie, Ill. ISI is acquiring the operating assets of Panellit, originally its parent company. Chance Vought will then buy unissued ISI stock.

Genesys, a wholly owned CV subsidiary, and Panellit will become separate operating units of the new electronics firm. Clifford K. Johnson, president of Genesys and a Chance Vought vice president, will be president and chief executive officer of the new organization. Albert Sperry, president of Panellit and ISI, will be chairman of the board and technical director.

General Telephone & Electronics centralized the responsibility for its government projects within Sylvania Electronic Systems, a division of Sylvania Electric Products. Sylvania Electronic will coordinate the defense systems capabilities of the various GT&E subsidiaries, including Automatic Electric, Leich Electric, Lenkurt Electric, Electronic Secretary Industries, and GT&E Labs.

Sylvania Products for its part announced it will build a new electron tube R&D center at Emporium, Pa. Plans call for completion this year of a facility for research on the Sarong cathode coating and on various types of "stacked" tubes. The division's chemical development research activities will also move to Emporium.

Boeing and Vertol merged. The swap was two shares of Boeing stock for three shares of Vertol.

Vertol's operations continue at Morton, Pa., under its original management as Boeing's Vertol Aircraft Division. Allied Research Associates, of Boston, Mass., and Canadian Vertol Aircraft, Vertol's wholly owned subsidiaries, are now subsidiaries of Boeing and continue as separate corporations under their own management.

The acquisition of Vertol complements Boeing's transport aircraft product line, according to William M. Allen, president, and provides the company with the basis for future programs in the short haul air transportation field.



How to get reliable missile maintenance

by **Joseph B. Smith, Jr.**, Mechanical Engineer,
Directorate of Civil Engineering, USAF*

RELIABILITY is a critical element of tactical missile operations. Missile systems, including their support facilities, must therefore be analyzed to find those areas in which delays, malfunctions, or failures can affect this vital factor. Maintenance especially must be carefully considered.

A variety of factors directly influences missile maintenance. For example, missile operation is geared to a complicated operating program and system of controls that can be affected by the malfunction of one small part or the delay or failure of some support action. In other words, the whole missile system operates on a go-no-go basis.

Unlike conventional aircraft, missiles can't be tested in trial flights. Reliability therefore depends on preflight checkouts, component and system testing, and maintenance. Preparation for launching is systematic and short. Complex and unusual maintenance with complicated test equipment is needed. Spare parts and equipment preservation demand the closest attention. Records must be complete and dependable. And no one knows just when the "button" will be pushed.

Effective missile system maintenance depends primarily on proper organization and personnel qualifications.

The maintenance organization must be fitted to the missile organization at every echelon, maintenance activities must be integrated into the overall scheme of military planning and operations, and staff and line functions must be defined. The staff plans, organizes, develops key personnel, directs, coordinates, and controls; the line executes, using administrative procedures which speed staff and line action, and maintains two-way mechanical communications through maintenance channels rather than through command channels.

Maintenance staff and line must include enough *qualified* personnel. These people must have a knowledge of design, construction, and operations as well as of maintenance of equipment, facilities, and systems. To use conventional craftsmen and mechanics to repair, replace, maintain, adjust and inspect seldom will be fully feasible. Key maintenance people must include engineers and engineer-technicians (the latter being trained

in engineering and the sciences as well as in crafts and specialties).

All missile personnel must understand the scope and objectives of the prescribed maintenance doctrine and practices. Understanding is most essential at the top echelons, where maintenance policy decisions are made and instructions to the field are drawn up. Lack of understanding at the top usually results in ineffective organization and lack of qualified personnel.

These are all broad factors. Many other, more specific factors also need serious attention from the maintenance standpoint: personnel and training criteria, loss of trained personnel to other military units and industry, office and shop space, spare parts procurement and storage, tools and test equipment, publications, transportation, language, preventive maintenance, etc.

New maintenance approach needed

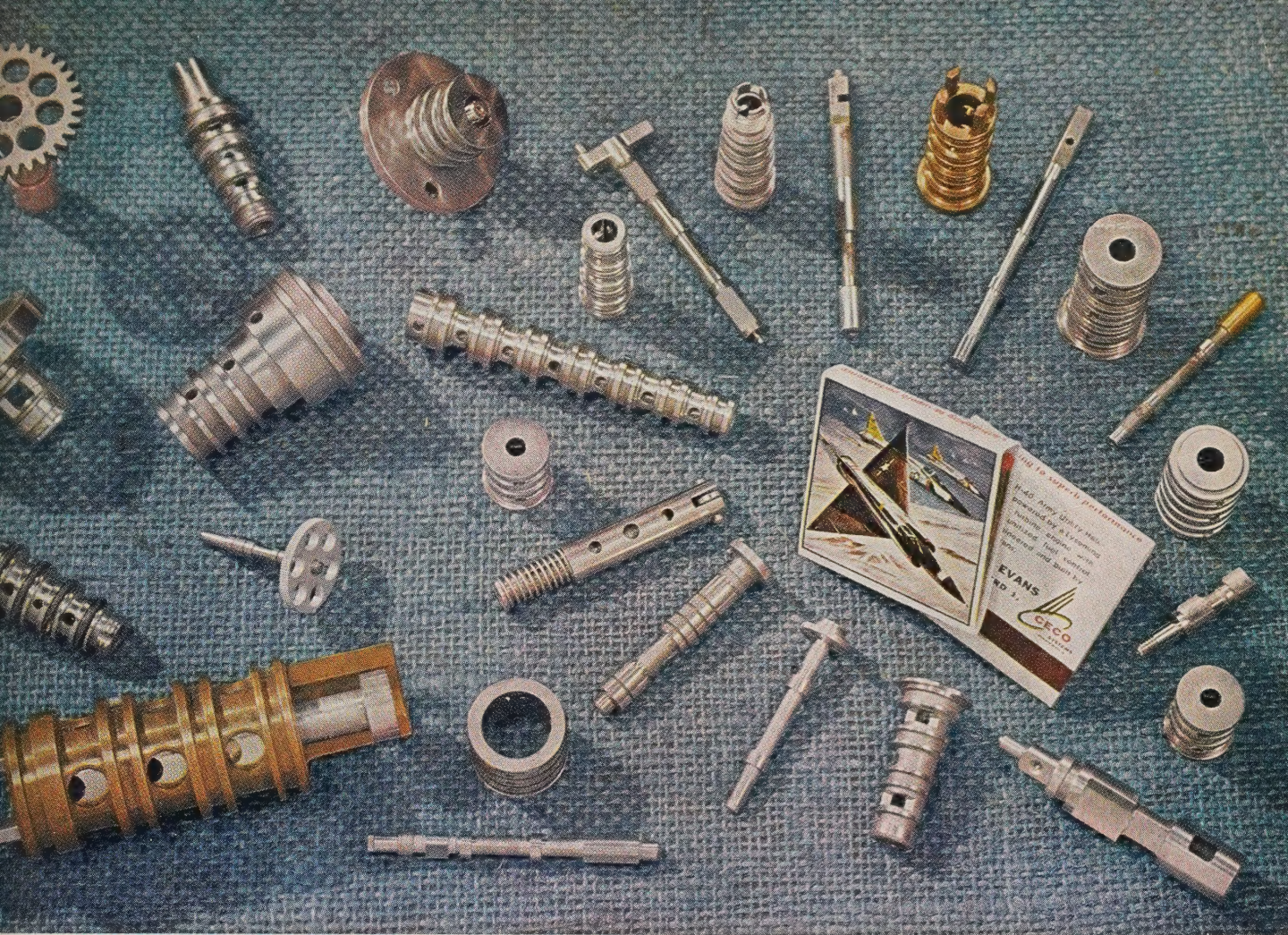
A new philosophy of maintenance, suited especially for missile systems, is needed — *now*. Maintenance should include *all* activities needed to eliminate or control *all* factors that hurt missile reliability. Therefore, the total operation should be maintained rather than the separate elements of a missile system. For such an approach, maintenance personnel must be proficient not only in engineering and the physical sciences, but in certain social sciences as well.

Confidence in maintenance doctrine and practices must be complete. Maintenance staff and line have confidence in their actions only when they have access to all necessary information. Other key staffs and units trust their maintenance support when they not only understand the doctrine, but also recognize that the maintenance measures that are actually applied are feasible.

The factors that cause component failures and delays are complex and interrelated. Only when these factors are found and "treated" or eliminated can maintenance be said to be truly preventive. Most importantly, true missile reliability cannot be achieved unless scientific facts and principles replace the rules of thumb and educated guesses too often used as basic tools by so many of today's maintenance experts.

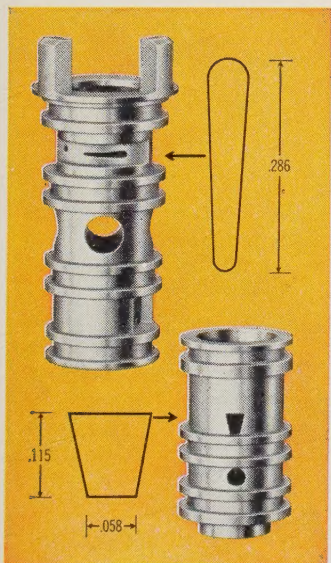
Contributions to this department may be on any subject technical or nontechnical, about which readers would like to air their views. Names and professional affiliations will be withheld on request.

* Directorate of Civil Engineering, Hq., U.S. Air Force, Washington 25, D.C.



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